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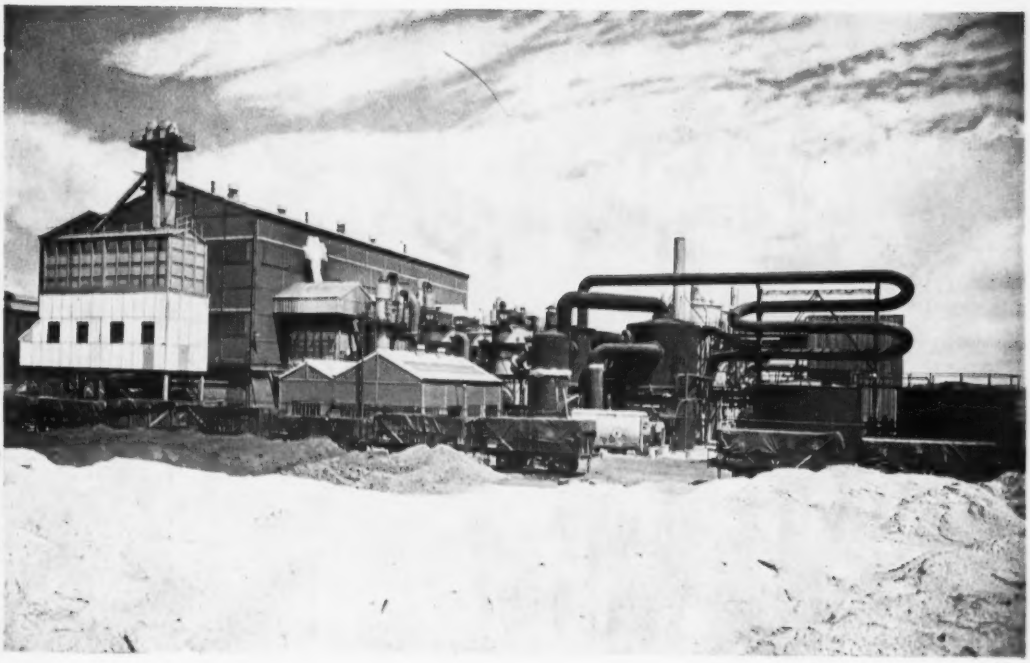

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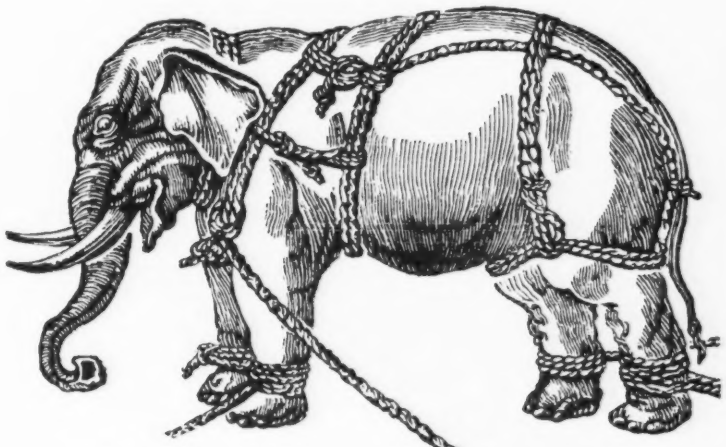

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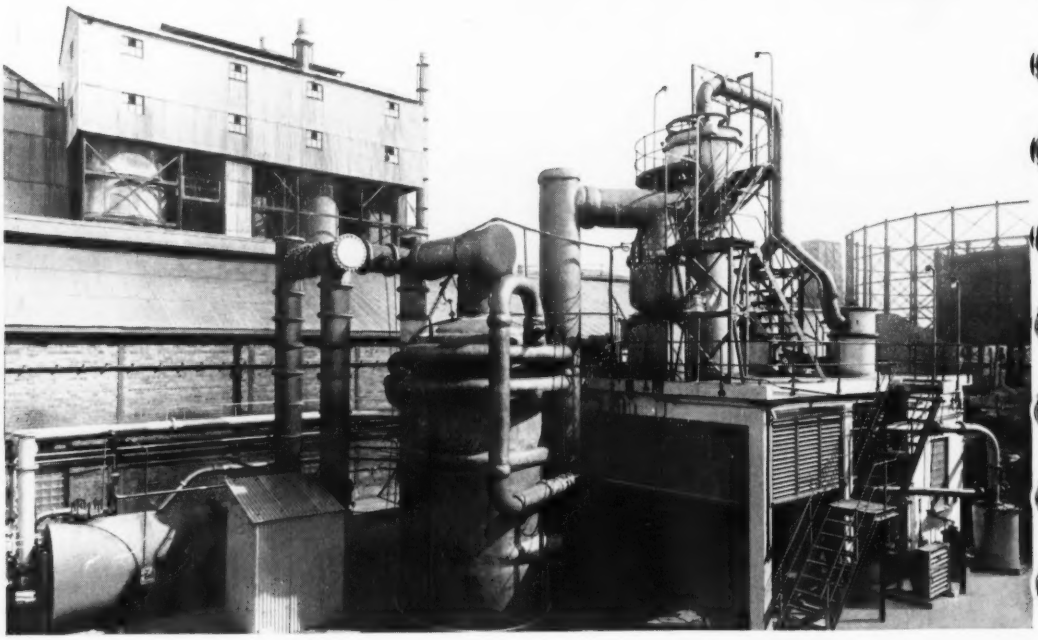

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QUARTERLY BULLETIN No. 12

MARCH 1956

ISSUED BY

THE BRITISH SULPHUR CORPORATION LTD.,
4, GRAFTON STREET,
LONDON, W.1.

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Telegrams : SULFEX, PICCY, LONDON

Cables : SULFEX, LONDON

Printed by The Essex Chronicle, Chelmsford, England

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FOREWORD

IN view of an ever increasing flow of enquiries on technical problems, we have decided to provide a consultancy service for our readers. A panel of consultants has now been established to which technical problems can be referred for expert and impartial examination and confidential opinion.

The scope of this service includes problems in the day-to-day production and consumption of sulphur in all forms, the critical examination of new projects and processes and advice on production methods.

Readers are invited to send their problems on which, after assessing the work involved, an estimate will be submitted for acceptance before detailed examination or recommendations are made.

This service, which aims at providing from a central focus a wide choice of expert advice will no doubt appeal to subscribers able to use outside assistance and co-operation with an international outlook; it should be regarded mainly as a valuable addition to the services which the British Sulphur Corporation already renders to its subscribers and to the sulphur industry.

March, 1956.

Review

SULPHUR, one of the most abundant indigenous raw materials of **Italy and Sicily,** occurs in all known and exploitable forms. Of the total sulphur output in 1955 of 890,000 tons, production of elemental sulphur based on the extensive rock sulphur deposits of Sicily and Central Italy accounted for 21%, the production of pyrites, centred primarily on the high-grade deposits of the Maremma in Tuscany, represented 68%, and the balance (11%) arose in the recovery, as by-product acid, of the sulphur contained in lead and zinc smelter gases, sulphur in spent oxide from coal gas cleaning and the use of crude sulphur ores in the production of low-grade ground sulphur and in sulphuric acid manufacture. Sulphur recovery from oil refinery gases, although feasible, is not practised, but the recovery of sulphur contained in geothermal steam is to start this year.

The deposits of sulphur rock in Sicily and Central Italy, which, exploited for several hundred years, have yielded to date about 33 million tons sulphur, were until the turn of the century the principal source of elemental sulphur in the world. With the advent of low-cost Frasch sulphur to world markets, the elemental sulphur industry of Italy and Sicily, essentially dependent on exports, started to decline as its competitive position became progressively affected by adhering to uneconomic mining and refining methods, unprofitable employment of labour, fragmentation of ownership, and by lack of capital. Finally, after 1952, the cumulative effect of those adverse factors, manifested by excessive production costs, knocked Italy out of export markets, which she was only able to re-enter last autumn following the Central Government's decision to rescue the industry by the

payment of export and production subsidies. The Ente Zolfi Italiani, the semi-Governmental organisation controlling all domestic export sales of sulphur as well as production, is thus enabled to dispose of current output as well as attempting to reduce the accumulated stockpile. The maintainance of a high level of production, and the remuneration to producers of their actual production costs, is dictated by the dependence of the regional working populations on this industry. New legislation by the Central and Regional Governments, in respect of the existing reconstrustion funds recently increased to Lire 12 billion, is intended to provide individual producers with the means to improve their production facilities and to give effect to the material side of the plans for the rationalisation and modernisation of the industry.

The overriding problem — the more efficient use of labour—is, however, social and political, and the provision of alternative employment for redundant sulphur labour must await the broadening of the economy of the regions in question, particularly in Sicily where the gradual expansion of new oil and fertiliser industries now holds out some promise.

Contrasting with the critical state of the elemental sulphur industry, the Italian pyrites production, 90% of which is contributed by the mines of Montecatini, has expanded over the past 20 years to become the fourth largest in the world. The industry, with the exception of token exports to established foreign customers, is based on the expanding domestic sulphuric acid manufacture and supplies about 80% of its sulphur needs. This predominant use of pyrites is to a large extent prompted by the resultant arising of high grade pyrites residues which form a welcome source of iron supply for the Italian iron and steel industry. Similarly the treatment of residues of domestic and imported curpreous pyrites economically supplies a substantial part of Italy's copper requirement.

The domestic use of elemental sulphur is confined to non-acid purposes, notably agriculture and rayon manufacture, and accounts for just over one-eighth of total sulphur usage of 823,000 tons in 1955. Italy's sulphuric acid industry—the third largest in Western Europe—produced in 1955 1.9 million tons (100% H_2SO_4) of which the acid/fertiliser plants of Montecatini accounted for 68%. Most other acid manufacturers are also engaged in fertiliser manufacture which takes up 77% of total acid use; the increasing indigenous use of crude sulphur ore and concentrates in sulphuric acid manufacture is significant as it promises to overcome the rigid division between the functions of the pyrites and native sulphur industries. As long as the real cost of Italian elemental sulphur exceeds its sales value on world markets and Maremma pyrites, due to their exceptional quality, are in demand by most acid makers in Europe, a closer integration in the domestic economy between these two sections of the sulphur industry must be desirable. The prominent part played by Montecatini in the production and use of sulphur in various forms holds promise that a correct balance will be established to the greatest advantage of the individual sections of Italian sulphur industry and the national economy as a whole.

In the **United States of America** production of Frasch and recovered sulphur in 1955 amounting to 6,144,994 tons was the highest on record, 4½% greater than output in 1954, the previous peak year. Prompted by the sustained high level of domestic demand, Frasch sulphur output in the last quarter of 1955 rose to an annual rate of over 6.6 million tons. Actual production capacity of sulphur domes remained practically unchanged, as the start of operations at Chacahoula dome promises to compensate for the closure of Hoskins Mound, while that of recovered sulphur plants increased by over 15%.

Under the impetus of booming activity, principally in steel, automobiles, rayon, pulp and rubber manufacture, the U.S. chemical industry experienced a record year in 1955, and in consequence, consumption of sulphur in all forms rose over 10% to about 5.6 million tons, representing the needs of the sulphuric industry, which produced about 14.9 million short tons virgin acid, and of the non-acid industries, which used 1.1 million tons sulphur. Apparent sales totalled 6,190,291 tons Frasch and recovered sulphur, an increase of 9½% over 1954, the previous peak year. Exports receded slightly to just under 1.6 million tons, and with imports of 60,000

tons Mexican Frasch sulphur, foreign sources made the first substantial contribution since prior to World War I. to augment domestic crude sulphur supplies. Nevertheless, stocks of Frasch and recovered sulphur declined 45,000 tons during 1955 to 3,291,789 tons.

The outlook for the sulphur - using industries in the U.S.A. reflects the general industrial picture, which points to an overall expansion of 3-4%, although there are indications that the demand for sulphur may rise more rapidly than industrial and agricultural activity in general. Among the new plant projects of the chemical industry, which plans to spend $1,125 million, some eight major acid plant projects will contribute to raise rated acid capacity to 19.3 million short tons. The construction of further new sulphur recovery units, and acid sludge and pickle liquor treatment plants will help to meet the rising demand, which in 1956 is estimated to reach 5.8-5.9 million tons sulphur.

The **Freeport Sulphur Company** achieved in 1955 the best financial results since its establishment 43 years ago. The company's sulphur production, totalling over 2 million tons for the second year running, included nine-months' output from the new Chacahoula dome, which is expected to compensate for the loss of output from Hoskins Mound, which was closed, exhausted, in May, 1955. Development work at Lake Pelto dome, the latest and very promising addition to the company's sulphur reserves, is going ahead, although in view of the location of the dome, off-shore under 6-8 feet of water, some time may elapse before the plant can be installed. Continued high level of sulphur production, already borne out by results, is expected in 1956.

According to the annual report of the **Jefferson Lake Sulphur Company,** sulphur production and sales in 1955 substantially surpassed the best achievements of previous years. The output of the company's three sulphur domes, augmented by recovered sulphur production from the new hydrogen sulphide extraction plant at Manderson, Wyoming, totalled 500,000 tons sulphur, 12% more than in 1954. In spite of peak sales, aggregate sulphur stocks appear to have increased by over 90,000 tons, and the company's net operating profit was 8½% lower than in 1954. Among its other activities, which include chemicals manufacture and various plant and process developments, the progress on a novel means of desulphurising natural sour gas promises to secure the company an important place in this rapidly expanding sector of the sulphur industry. In its established sulphur activities the company look forward to favourable results in 1956.

The **Stauffer Chemical Company,** one of the major chemical concerns in the U.S.A., is the largest producer of industrial and agricultural sulphur chemicals. Operating 48 plants and establishmments, and supported by 10 plants operated by affiliated companies, its activities include the manufacture of sulphuric acid, in which the company ranks amongst the top six U.S. producers. Accounting for about one-third of total U.S. output, Stauffer is the largest single producer of carbon disulphide, and its manufacturing facilities include plant to react molten sulphur with methane, a new process developed by the Food Machinery and Chemical Corporation, which is operated under licence. The company's sulphur requirements, which are met primarily in the form of Frasch sulphur, are estimated to total ½ million tons annually, or about 10% of total U.S. consumption.

Production of Frasch and recovered sulphur in **Mexico** in 1955 totalled 503,000 tons. As the result of continued expansion by the largest producer, Pan - American Sulphur Company, their output rate at Jaltipan dome at the turn of the new year reached an annual rate of 800,000 tons. Mexican Gulf Sulphur Company having relocated their production wells to a more favourable part of the San Cristobal dome, are confident of speedily achieving a consistently high level of output. Gulf Sulphur Corporation, whose plant at Salinas was completed in January, has deferred the start of steaming operations. Although exports and deliveries to the growing home market are expanding, the stock-pile of sulphur is mounting rapidly, and is at present in excess of ½-million tons.

In the **United Kingdom,** consumption of sulphur in all forms in 1955 amounted to 1,077,000 tons, 3½% more than in 1954, the previous peak year. As the result of greater

anhydrite output to meet the requirements of the three new acid plants at Billingham, Widnes and Whitehaven, and increased recovery of sulphur from oil refinery gases, indigenous sulphur supplies rose 13% to about 540,000 tons. While consumption of sulphur for non-acid purposes declined slightly (1¾%) to 113,000 tons, anhydrite use in direct manufacture of sulphate of ammonia expanded to about 201,000 tons sulphur, and the requirements of the sulphuric acid industry rose 4½% to 763,000 tons. Increased availability of anhydrite acid affected primarily the use of pyrites and spent oxide, while compared with 1954, acid sulphur use increased 5½% to 272,700 tons. Raw material use in the last quarter of 1955, when acid production at an annual rate of 2¼ million tons reached the highest level on record, emphasised the changing trend. Sulphuric acid production in 1955 amounted to 2,117,000 tons, 3¾% more than the peak output in 1954. Effective production capacity, which during the year expanded by 220,000 tons (9½%), amounted to 2.58 million tons, and of this 81.2% was employed. Acid consumption, mainly under the impetus of greater requirements in the manufacture of superphosphate, titanium dioxide, rayon, detergents and steel, increased to 2,137,000 tons, 4½% more than the peak year of 1954. The steep rise in sea freights nullified the reduction of 9% in imports of brimstone and pyrites, and the total import bill for sulphurous raw materials rose fractionally (¼%) to £9.15 million.

The outlook for 1956, the first year since 1939 that the sulphur industry is entirely free from Government control, points to no more than a moderate increase of sulphur needs in view of the slowing down of the expansion rate of industrial production as a whole. More than one-half of the anticipated requirement of about 1.1 million tons should be met from indigenous resources, primarily as the result of the greater anhydrite needs of the new acid plants, which should supply about 17% of the anticipated acid output of up to 2.2 million tons. After a period of adjustment, of not more than six months, the present trends of greater anhydrite and elemental sulphur use should then be clearly established in the new pattern of raw materials of consumption.

The new treatment plant of **Nairne Pyrites Limited,** at Brukunga, South Australia, which was officially opened on 13th February, 1956, is described in detail. Its supply of pyrites concentrates, at an annual rate of about 30,000 tons sulphur, to the new plant at Birkenhead of Sulphuric Acid, Ltd., which was built as a part of an integrated project, does not, however, permit acid production competitively with imported brimstone, and the company's operations qualify for the subsidy under the Federal Government's bounty scheme.

The **world price** structure of sulphur was significantly changed in February, when the Freeport Sulphur Company reduced their export prices for bright and off-colour sulphur by $3 to $28 and $27 per ton f.o.b. respectively, thereby eliminating the earlier differential between domestic and export prices. In consequence, about one-half of the world trade, including Mexican, Chilean and Italian sulphur exports, is now based on this lower price level, whereas all other U.S. sulphur exporters continue to base their export price on $31 per ton f.o.b. Export prices of European pyrites remain unchanged, although a recent improvement in the value of residues makes pyrites use on the Continent slightly more favourable than hitherto. The outlook for brimstone prices remains weak whereas in the case of pyrites the possibility of an increase notably of Spanish pyrites cannot be excluded.

The **world supplies** of elemental sulphur continue to increase, primarily as the result of the high level Frasch sulphur production in the U.S.A. and Mexico. Rising domestic demand in the U.S.A. is being met and U.S. producers continue to promote sales in export markets where strong competition is encountered from Mexican and Italian supplies, the latter in markets offering a freight advantage. Production of sulphur in all forms in 1955 of 14.2 million tons was 6% greater than in 1954 while consumption expanded by 7% to 13.8 million tons. The additional supplies were almost exclusively in the form of brimstone, notably Mexican Frasch sulphur. Stocks of Mexican and Italian sulphur, at present totalling over 800,000 tons, are expected to increase and exert growing pressure on world markets.

THE SULPHUR INDUSTRY OF ITALY AND SICILY

General

Sulphur is one of the most abundant indigenous resources and it occurs on the Appenine peninsula in all known and exploitable forms. Although the production in Sicily and Central Italy of elemental sulphur from sulphur rock, which until the turn of the century was the largest in the world, is of greater significance to world sulphur trade, the exploitation of the substantial pyrites resources yields at present not only a much larger supply of sulphur but it provides the predominant source of sulphur to the domestic sulphuric acid industry. Apart from modest quantities of by-product sulphuric acid obtained from sulphur contained in non-ferrous, predominantly zinc, smelter gases, sulphur recovery is not practised. Oil refineries flare-off the H_2S contaminated gases, the coal gas industry provides only negligible amounts of spent oxide suitable for acid manufacture and is itself losing ground in view of the rapidly increasing use of abundant natural gas supplies which, being practically pure methane, do not represent a source of sulphur.

The elemental sulphur industry stands to-day at a critical, but not any longer hopeless, stage in its long and varied history. Although its relative importance has been declining since the emergence of the U.S.A. as a supplier of cheap Frasch sulphur, it was nevertheless able to fulfil, up to the outbreak of World War II, the vital task of providing a substantial part of the needs of European sulphur users. Throughout this period antiquated and uneconomic mining and refining methods, unprofitable employment of labour, fragmentation of ownership, and lack of capital were increasingly affecting its competitive position, and although a succession of government commissions and boards were set up with a view to promoting greater efficiency in the industry, it was mainly on account of marketing agreements with U.S.A. producers that a semblance of prosperity could be maintained.

Centralised control of marketing has been a feature of the Italian industry for the past sixty years. Long before the emergence of the U.S.A. as challenger of Sicily's world monopoly, the unstable conditions of the industry were manifested by repeated over production and consequent heavy price fluctuations.

Control was first attempted with the blessing of the Italian Government by British commercial interests who in 1896 formed the *Anglo-Sicilian Sulphur Company* with a view to acquiring as large a share as possible of Sicilian output and ensuring its orderly disposal.

Its dissolution ten years later resulted in the first attempt by any Government at collective control of a major export industry, and the authorisation by the Italian Parliament of a Sulphur Consortium established the precedent on which the present *Ente Zolfi Italiani* is based. Governed by a board† consisting of representatives of the Government and the sulphur producers, the E.Z.I. purchases the sulphur output of all producers at prices based on the production costs of the entire industry, and effects all sales to the home and export markets. In recent years rising costs of production, especially amongst the smaller mines, led to repeated increases in the sales price which finally knocked E.Z.I. out of export markets. The accumulation since 1952 of the unsold export surplus reached a total of over 350,000 tons by mid 1955 and continued production at costs more than double those of ruling world sulphur prices resulted in a deadlock which was only resolved last year by Government intervention in the form of subsidy payments both to producers and to the E.Z.I.

In contrast with the difficulties of the elemental sulphur industry, pyrites production, wholly controlled by private enterprise, has expanded consistently, so that in doubling its capacity over the past twenty years Italy is to-day the fourth largest pyrites producer in the world. Contributing over 90% of total

†Chairman: Ing. Franco Lanza di Scalea. Directors: Avv. Antonio Castellet (Managing), Comm. Corso Capone, Dott. Carlo Faina, Dr. Guiseppe La Barbera, Dr. Spartaco Lanza, Baron Ferdinando Morillo di Trabonella, Rag. Aldo Nicosia.

output are the mines of *Montecatini* in the Maremma region of Central Italy, in the form of high grade pyrites of exceptional purity. Although they are in great demand by other European pyrites users, their predominant use in domestic sulphuric acid manufacture is largely determined by the resultant supply of high grade residues to the Italian iron and steel industry.

It is estimated that sulphur production in all forms in 1955 totalled 890,000* tons of which 66% was accounted for by pyrites, 21% by elemental sulphur, and 11% by sulphur in blende, spent oxide and sulphur ore.

Mainly under the impetus of rising fertiliser requirements, domestic sulphur consumption has been increasing steadily and in 1955—amounting to about 823,000 tons—was about 78% greater than in the late thirties and about 50% up on 1950. The use of elemental sulphur remains confined to non-acid purposes, principally rayon manufacture and agriculture, and accounts for little more than one-seventh of total usage. Sulphuric acid manufacture which in 1955 totalled nearly 1.9 million tons (100% H_2SO_4) is predominantly based on the use of pyrites augmented by a small tonnage of by-product acid recovered in non-ferrous metal smelters, although in recent years the use of crude sulphur ore and concentrates has been increasing. Pyrites imports, mainly from Cuba, Cyprus, Greece and Spain, are needed to supplement domestic production, a small proportion of which—103,000 tons in 1955—enters export markets to selected and long established users of Italian pyrites.

Exports of elemental sulphur were resumed in the autumn of last year, after an interval of nearly three years, and in the remaining months of 1955 a total of 46,800 tons was shipped to neighbouring countries where Italian sulphur enjoys a freight advantage compared with shipments from the Gulf of Mexico.

To achieve competitive status in export markets, the industry now relies on subsidies, which do not, however, provide a lasting solution. Its main hope rests in the effective use of capital provided by the Central Government in the form of a reconstruction fund, recently raised to 12 billion Lire, from which, with the aid of related measures by the Regional Governments, producers can meet the cost of plant and mine modernisation designed to lower their costs of production.

Sulphur Ore Deposits

The principal deposits of sulphur rock are in Sicily and Central Italy. The deposits in Sicily extend in an irregular belt some 80 miles long and 35 miles wide, with main centres around Caltanissetta and Agrigento. On the mainland, deposits are found in Romagna, Marche, the Avellino area, and Benevento. The grade of mined ore varies between 17-35% sulphur, though pockets of rich material up to 70% occur, while extensive strata of lean ores, below 15%, are generally ignored.

The Sicilian deposits are predominantly of sedimentary origin, and it is generally held that hydrocarbons from the underlying carbonaceous limestone and shale layers have reduced gypsum to lime and sulphur. Similar formations also occur on the mainland, where there are also impregnation deposits formed by the action of acid springs rich in sulphurous gases.

In Sicily active mining has been largely confined to outcrops, in locations where erosion, faulting and fracturing, have been considerable. This largely accounts for the great number of small deposits being worked under adverse conditions, since the sulphur strata are generally found lying at steep angles.

Geophysical oil prospecting, which is increasingly meeting with success is said to be confirming the existence of deep-lying undisturbed sulphur strata which may be amenable to exploitation by the Frasch process.

Sulphur deposits, notably those in Sicily, have been exploited for hundreds of years. Since 1870 some 28 million tons fused sulphur have been produced and it is estimated that prior to that, production totalled about five million tons. The actual quantity of sulphur mined to date is probably almost twice as great due to the inevitable sulphur losses incurred in refining ore by fusion.

The number of sulphur mines is estimated to total more than 500, although at present less than 200 are being exploited.

*All quantities in metric tons.

Mines
Sulphuric Acid Plants
Viscose Rayon Plants
Carbon Disulphide Plants
Principal Sicilian Sulphur Mining Areas
Agordo
Calceranica
Champ de Praz
Brosso
Venice
Milan
Turin
Genoa
Sestri Levante
Formignano
Farnocchia
Florence
Perticara
Ligurian Sea
Larderello
Cabernardi
Adriatic Sea
Niccioleta
Bacchegiano
Gavorrano
Grosseto
Rigoloccio
Elba
Collestatte
Giglio
Manziana
Rome
Naples
Sardinia
Tyrrhenian Sea
Monteverchio
Cagliari
Caltanisetta
Catania
Porto Empodocle
Agrigento
40 20 0 50 100
MILES

Fig. 1.

Mining and Refining

In general the sulphur deposits are wide, varying from 20-60 feet, and steeply inclined at angles 30° to 80°. Sulphur occurs in thin veins and small pockets in limestone, often parted by shale and gypsum, and embedded in walls of similar soft rocks. In consequence, adit openings are rarely wider than 1.5-2 metres, and 30 metres on strike. To minimise rock falls, close filling and stall support is practised and deposits are mined in slices. Fire hazard is great and notwithstanding the use of special explosives, outbreaks are frequent, often caused by the friction of rock movement or explosion of methane gas from footwalls. Because of these adverse characteristics large scale, mechanical bulk mining methods, which the natural width of deposits might warrant, cannot be applied universally, although in practically all the larger mines certain aspects of the mining operations would lend themselves to modernisation, primarily ore transport, filling, hoisting and ventilation. This has been proved at the Trabonella mine, one of the three largest deposits, where extensive mechanisation and rationalisation of mining operations were successfully completed last year.

The crucial factor remains the employment of labour. Although the number of workers engaged in sulphur mining in Sicily now totals only 9,000-10,000, compared with four times this number at the turn of the century, any redundancy as the result of mechanisation would cause, in view of limited opportunities for alternative employment, a major social problem. Furthermore, the militant policy of the Communist-controlled miners' union is primarily concerned in increasing the number of those employed without much regard for the economic effect on the industry. The fact remains that overall labour efficiency is very low and output per worker is only about one-half ton of sulphur ore per day.

Ore Refining

With the exception of a small number of modern concentration and refining plants installed during the past two to three years, the entire industry practices refining methods unchanged in principle since sulphur was first produced, whereby sulphur is melted from its gangue by the heat of its own combustion. The earliest crude pits were replaced in the 19th century by calcaroni—conical kilns some 35-60ft. in diameter, 8-18ft. deep and rising some 10ft. above the surface—into which ore is heaped and ignited, the molten sulphur being collected in a surrounding ditch. By this method up to one-half of the sulphur content of the ore may be recovered and though largely replaced to-day by the Gill furnace, some calcaroni are still in use.

The Gill furnace, introduced about 1880, consists of two or more interconnected cells into which ore is charged. The charge in the first cell is ignited and the combustion gases are carried forward to the next cell, where they cause spontaneous combustion of the charge when air is admitted. Suphur recovery in Gill furnaces of up-to-date design can be as high as 75%, but generally lies between 50-60%. The resultant sulphur is classified in four grades, Gialla Superiore (min. 99.5%), Inferiore (min. 99%), Buona Sicilia (min. 98%), Corrente (min. 95%), the quality of the output being dependent on the original composition of the crude ore and the empirical skill of the furnace operators.

In view of the low productivity of the mines and the relatively lean ores, the refining losses incurred in the established fusion method of sulphur production are a major contributory cause of the high production costs. The introduction of modern refining methods and plants, based on ore concentration and fusion, retort distillation, mechanical separation or a combination of such processes, which are designed to permit sulphur recovery of at least 80% of the ore content, has however been slow. This is partly on account of difficulties in raising the necessary capital for such projects—a major problem to an impoverished industry—which the recent provisions of the Federal and Regional Governments' assistance bills were designed to overcome. Primarily, however, they are due to the inherent structure of the industry, which consists of a large number of small scale operators and only few major producers to whom modern plant might show significant savings.

During the past three years the following new plants have been installed:—

Mine	*Type of Plant*	*Capacity Ore per day*
Val Salso ...	Humboldt Flotation ...	800 tons
Cozzo Disi ...	Denver Flotation ...	800 „
Montecatini :		
Perticara ...	I.S.P.I.	100 „
Passerello ...	Montecatini—Lurgi ...	130 „
Cia Generale Zolfi		
Saponaro ...	I.S.P.I.	100 „

Production

In 1955 total output of fused sulphur amounted to 185,000 tons, 9½% less than in 1954. Output of sulphur ore, amounting to 1,661,500 tons (containing 15-30% sulphur), also provided the means of producing 21,500 tons ground sulphur containing about 30% sulphur for direct use in viticulture and 270,000 tons (containing an average of 20-23% sulphur) in crude form as raw material for sulphuric acid manufacture. The most recent

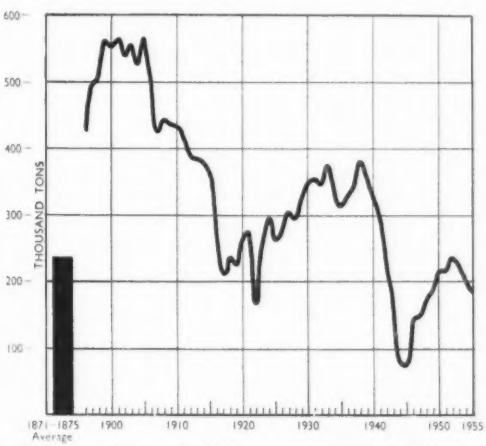


Fig. 2. Elemental Sulphur production 1895-1955.

development at Manziana in Central Italy* is the first measure of its kind designed to enrich sulphur ore sufficiently to provide an attractive raw material for acid manufacture. Output at the Manziana project in which Montecatini have a major interest is expected to rise by the end of this year to 6,000 tons of sulphur concentrate containing 50% sulphur.

The following table shows distribution of active producers in 1954:—

	SICILY		*MAINLAND*	
Annual Capacity of fused sulphur	*No.*	*% of output*	*No.*	*% of output*
Over 10,000 tons ...	1	10.35	2	64.06
9,000-10,000 „ ...	2	12.44	—	—
8,000-9,000 „ ...	1	5.86	1	15.12
7,000-8,000 „ ...	2	10.08	—	—
6,000-7,000 „ ...	2	8.67	—	—
5,000-6,000 „ ...	1	3.93	1	8.69
4,000-5,000 „ ...	3	9.03	1	7.09
3,000-4,000 „ ...	2	4.52	—	—
2,000-3,000 „ ...	7	11.32	1	3.40
1,000-2,000 „ ...	7	5.97	—	—
500-1,000 „ ...	14	6.48	—	—
Under 500 „ ...	141	11.35	1	0.69
Total output (metric tons) year ending 31/7/1954 ...	183	151,618	7	59,388

In 1955 Sicilian producers contributed 147,920 tons (80%), while 36,844 tons (20%) was produced on the mainland.

TRABONELLA

This, the largest sulphur mine in Europe, situated eight miles north of Caltanissetta in central Sicily, is owned by Dr. Fernando Morillo, Baron Trabonella. It consists of four separate sections: Luzzati, Aureo, Santa Luisa, and San Francesco, of which the first three are developed and the last named reserved for future exploitation. Proved reserves amount to over six million tons sulphur ore, containing an average of 25-30% sulphur. With the aid of E.R.P. and Italian Government funds, the underground workings and most of the installed machinery were modernised in recent years at a cost of over 500 million Lire (£280,000).

The actual mine workings are reached by three main pit shafts, about 300 metres deep, of which the third was constructed recently and equipped with German machinery, including twelve moving platforms and twelve conveyor belts. Sulphur refining is carried out in Gill furnaces, but the construction of a modern refining plant, probably a flotation unit, is foreseen.

The output arises in approximately equal proportions in the form of Gialla Superiore, Inferiore and Buona Sicilia, but it is claimed that both lower grades have a sulphur content in excess of 99%, although their colour does not come up to the standard of top-grade material. Annual output is at present about 12,000 tons, about two thousand tons less than the post-war peak in 1949. In addition to the requirements for ore refining, varying quantities are sold in crude form, primarily for sulphuric acid manufacture by Montecatini. The mine employs eight hundred miners.

MONTECATINI

Up to 1950 the bulk of the Company's output originated from mines on the mainland, notably the Cabernardi mine which for many years had been the largest single producer in the country. In latter years the grade of ore had become progressively lower and the gradual exhaustion of ore even as low as 8% led to the virtual closing of the mine in 1954.

Whilst intensive exploration in the Romagna-Marche region, aimed at discovering

*See Quarterly Bulletin 11, Page 30.

a deposit to take the place of Cabernardi, proved fruitless, satisfactory results were obtained in the Viterbo area, where in addition to the Latera deposits, operations were started recently at Manziana. Both are low grade impregnation deposits (solfatariani) of sulphur mixed with marcasite, with ore ranging from 6-25% sulphur and the output is concentrated by flotation to 50% to make the ore suitable for use in acid plants.

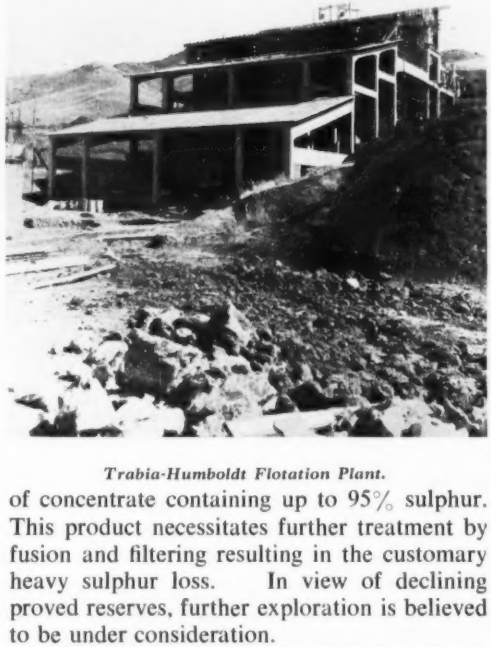
Perticara, already Montecatini's principal sulphur producing mine, promises further expansion in view of adequate reserves. In July, 1955, exhaustive trial operations were completed on a new Masobello plant based on retort distillation, built by I.S.P.I. Consuming 100 tons per day of ore containing average 20% sulphur, the plant permits a recovery of 80-85%, giving daily output of about 9 tons of 99.9% refined sulphur. At Formignano ample reserves, especially in the Montemauro district, which were surveyed in 1953, assure the continuity of operations.

The company resumed mining operations in Sicily in 1950, at first at the Passarello mine, in which Montecatini acquired a major share, and subsequently extended its sulphur mining activities to Bosco e Dragaito, Stincone, Pilaciocchi, and Apaforte. Extensive reconstruction at all these mining properties has enabled Montecatini to raise the level of output, part of which is refined, part delivered in crude form for acid manufacture. At Passarello Montecatini have installed a new Montecatini-Lurgi type refining plant, which is giving satisfactory results in the course of current trial operations. It has an ore capacity of 130 tons per day and permits 85% sulphur recovery on ore containing 20%. Its annual capacity is 8,000 tons fused sulphur.

The Stincone mine, operated by Montecatini's associate company, *Società Miniere Apaforte, Pilaciocchi e Stincone (S.M.A.P.S.)*, continues to produce at a level of about 7,000 t.p.a. of fused sulphur and 44,000 tons crude ore. In 1955 output from Montecatini mines on the mainland and in Sicily amounted to 32,200 tons, 17.4% of total Italian production.

OTHER MAJOR MINES

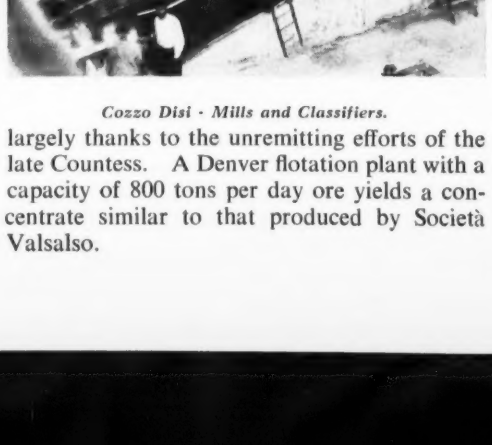
The *Società Valsalso* exploits the Trabia and Tallarita mines. In recent years improvements to underground workings have been carried out, and the bulk of the increased ore output is treated in a Humboldt flotation plant, installed in 1954, which is capable of treating 800 tons per day ore. By means satisfactory sulphur recovery is obtained in the form



Trabia-Humboldt Flotation Plant.

of concentrate containing up to 95% sulphur. This product necessitates further treatment by fusion and filtering resulting in the customary heavy sulphur loss. In view of declining proved reserves, further exploration is believed to be under consideration.

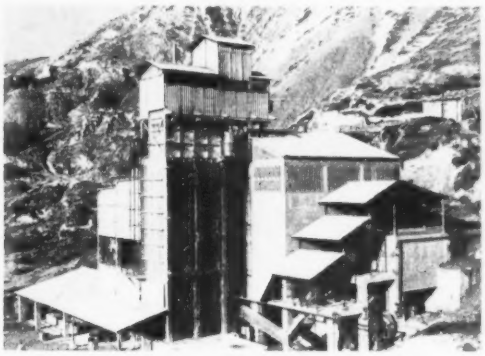
The Cozzo Disi mine owned by *Count Perrier* is amongst the most modern in Sicily,



Cozzo Disi - Mills and Classifiers.

largely thanks to the unremitting efforts of the late Countess. A Denver flotation plant with a capacity of 800 tons per day ore yields a concentrate similar to that produced by Società Valsalso.

The *Compania Generale Zolfi* has recently carried out a measure of mine modernisation at Saponaro with a view to providing an adequate output for a new I.S.P.I./Masobello distillation refining plant, which is due to come on stream later this year.



Saponaro - Masabello/I.S.P.I. Refining Plant.

The *Irpinia* mines are almost exclusively engaged in selective mining of an ore containing 30% sulphur or more for the production of crude ground sulphur, of which they are believed to be the only producers.

Awaiting rehabilitation is the Lucia mine of the *S.M.I. Sicula Mineraria*, 4½ miles north of Porto Empedocle. Flooded since 1915, the mine has reserves of 3-4 million tons ore, containing average 23%S, and recent exploration disclosed a further substantial ore body. With the aid of Government funds the company intend to instal modern mining and refining plant.

Pyrites : Deposits and Production

The centre of the Italian pyrites industry is the Maremma district of Tuscany. Encompassing an area of several hundred square miles, the Maremma deposits extend below the Tyrrhenian sea, and the exploitations on the islands of Giglio and Elba point to the existence of vast submarine reserves. The bulk of the Maremma pyrites are high grade and exceptionally pure, containing about 48% sulphur, 38-42% iron and are practically free from arsenic, copper or any other metallic impurities.

Pyrites deposits also occur, although on a much smaller scale, in the Riviera foothills, the Graian Alps (Val d'Aosta), the Belluno Alps, and the Western Dolomites. These deposits contain primarily high cupreous ore and until the early thirties accounted for a substantial part of Italian output. To a large extent the original mine workings are exhausted, but in several instances new exploration has disclosed additional workable reserves. Finally the complex lead-zinc sulphide ore deposits of Sardinia and Maremma make a significant contribution to Italy's pyrites resources, since the differential flotation of these ores gives rise to the production of a satisfactory grade of flotation pyrites containing 40-42% sulphur.

By far the most important producer is *Montecatini*, who directly and through associate companies control practically all pyrites mines. Total Italian production in 1955 amounted to 1,290,000 tons, of which 90% was contributed by Montecatini.

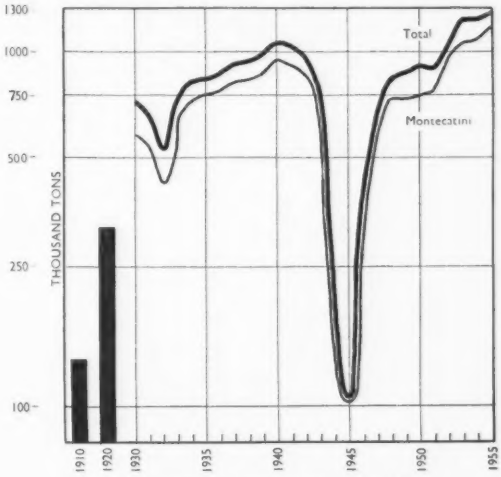
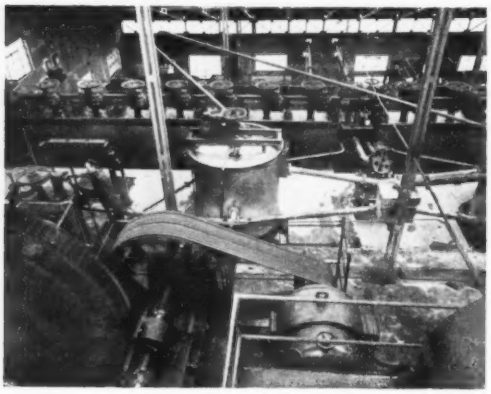


Fig. 3. Pyrites Production 1930-1955.

In the Maremma district Montecatini's current activities are centred on the Rigoloccio, Bocchegiano, Gavorrano and Niccioleta mines. Extensive mechanisation of all mines has been effected during the past six years, in addition to major works on drainage and underground ore movement facilities.

At Bocchegiano, a new drainage tunnel completed in 1955 has substantially raised exploitable reserves, and, with the addition of new crushing and flotation installations, the mine has now a capacity of 230,000 tons per annum. A new shaft sunk at Gavorrano in 1954 has appreciably raised mine capacity to

400,000 tons per annum and led to a corresponding expansion last year of the ore treatment plant. At the Fenice Accesa mine, also in Maremma, exploration in 1954 disclosed substantial additional reserves of mixed ores and the flotation plant, with an increased capacity of 168,000 tons per annum ore yields, in addition to blende and galena, chalcopyrites containing 42% sulphur, 2½% copper, at a rate of 14,000 t.p.a.



Bocchegiano - Pyrites Flotation Plant.

On the Island of Elba, after meeting considerable difficulties, major improvements of the mine and a new washing plant at Ortano were completed last year, permitting an annual output of 22,000 tons. This is assured for many years by the existence of adequate ore reserves. Underground expansion and modernisation of the washing plant at the mine on the island Giglio, in the Tuscan Archipelago, promise a substantial increase on last year's output of 24,000 tons. The above sea level reserves of this deposit are practically exhausted, but work below sea level is likely to expand, as the extensive reserves are so far not fully determined.

Operations at the Libiola mine near Sestri Levante, which Montecatini acquired by taking over the assets of the former owners, Manganesifera Italiana S.A., in 1953, are expanding, following the renewal and enlargement of the ore flotation plant that permits the production of 13,000 t.p.a. of chalcopyrites containing 40% sulphur, 6.8% Cu. This output is assured for more than 10 years. The mine has a long history of intermittent small scale operations—up to the early thirties it was associated with a British company, who produced copper sulphate from leached cupreous residues.

The North Italian pyrites mines at Brosso, Agordo, and Calceranica, produced about 164,000 tons in 1955. Their output, which includes cupreous pyrite, represents 14.3% of Montecatini's total production, practically no change from their pre-war share of 15% in 1935.

The most important producer next to Montecatini is *Marchi*, whose mines are situated close to the former's Gavorrano mines in the Maremma. Producing ore of similar good quality, Marchi's current output amounts to 70,000-100,000 tons pyrites annually. During the war the Marchi mines were severely damaged, and it is only since about 1950 that production could be resumed. The present rate of output corresponds to pre-war activities.

The *Soc. Toscana Industria Mineraria Affini (S.T.I.M.A.)* of Genoa operate the Riotorto mines at Grosseto in the Maremma region and the Farnocchia mine near Lucca. Their output is intermittent, and in recent years has not exceeded 10,000 tons per annum. The company is associated with Alais, Froges & Camargue of Paris.

The *Brambilla Company* own a small mine, Champ de Praz, in the Val d' Aosta, producing intermittently small quantities of cupreous pyrites and in the same valley at Traverselle, *Cogne* is producing pyrite by flotation.

The *Co-operativa Cremonese*, operate a small cupreous pyrites plant at Chiavari, not far from Montecatini's Libiola mine. Its output of 5,000-6,000 t.p.a. pyrites, containing 48% S, 2% Cu, is captive and consumed at the Company's acid plant at Soresina.

Ferromin operate a pyrites flotation plant on the Island of Elba in connection with their iron ore mining operations. The *Soc. Monteponi S.A.*, exploiting complex lead-zinc sulfide ore deposits on Sardinia, produce annually about 40,000 tons pyrites flotation concentrates.

Sulphur in Other Forms

The principal source of sulphur recovered from natural and industrial gases are the exit gases of the zinc and lead smelters. The

resultant by-product sulphuric acid output, detailed below, represented the use of 28,600 tons sulphur in 1955.

Company	*Production (100% H_2SO_4)*
Montevecchio, Italiana del Piombo e dello Zinco	23,700 tons
Soc. Pertusola at Crotone ...	30,000 tons
Soc. Monteponi at Iglesias ...	9,000 tons
SAPEZ at Ponte Notta	28,000 tons

Although the bulk of the crude oil processed in Italian oil refineries is of Middle East origin, and in consequence contains up to 2½% sulphur, sulphur recovery is not practised. The question does not arise in the case of natural gas of the Po-plain, production and use of which is rapidly expanding, as this is sulphur free.

On the other hand, the steam vents at Larderello, in Tuscany, the thermal energy of which is utilised by "*Larderello S.p.A.*" in electricity generating, contain small recoverable quantities of sulphur in the form of hydrogen sulphide. The large volume of vapour emission, up to 60,000 cubic metres per hour, containing an average of 20 grammes per cubic metre (9 grains per cubic foot) sulphur, is expected to permit the recovery of 9,000-10,000 tons sulphur annually, by the use of ferric oxide as absorbing agent from which sulphur will be extracted by an organic solvent. The experimental plant, built in co-operation with Bamag of Giessen, is now being expanded to commercial scale, and operation is due to start later this year.

Sulphur recovery from coal gas is restricted to about 8,000 tons sulphur annually in the form of spent oxide.

The production of crude sulphur ore for uses other than refining is rapidly assuming greater importance. Apart from the traditional though small scale production of crude ground sulphur (30% sulphur), crude ore and ore concentrates (50% sulphur) are increasingly used in sulphuric acid manufacture. In 1955 about 60,000 tons sulphur, 14% more than in 1954, was produced in this form.

Summarising the above details, total output of sulphur from all sources amounted to 890,000 tons in 1955, 4.3% more than in 1954. Of this total, elemental sulphur accounted for 185,000 tons, pyrites 608,000 tons, and sulphur in other forms 97,000 tons.

Consumption

Total consumption of sulphur in all forms in 1955 amounted to 823,000 tons, 5% more than in 1954 and was made up as follows :—

	Brimstone	*Pyrites*	*Blende*	*Other*	*Total*
		Thousand Tons Sulphur.			
1950	88.0	399.0	24.0	27.0	538.0
1951	148.6	466.5	24.5	51.0	670.6
1952	79.3	417.0	29.0	44.7	570.0
1953	82.0	508.4	27.6	51.6	669.6
1954	107.3	582.9	32.3	50.9	773.4
1955	107.2	619.4	28.6	68.0	823.2

The use of elemental sulphur is wholly confined to non-acid purposes. Since the economic crisis of 1952, which among sulphur using industries particularly affected Italy's rayon industry, consumption has expanded by nearly 50%. Subject to fluctuations in agricultural use, which is influenced by weather, and which accounts for more than one-third of total usage, elemental sulphur requirements are expected to expand at an annual rate of 8-10% in the next three years, to a level of about 150,000 tons by 1958. All other sulphurous raw materials, except for 8,000-10,000 tons sulphur contained in sulphur ore, used in the preparation of ground sulphur for agricultural use, are consumed in the manufacture of sulphuric acid. At present the requirements of the acid industry are not being met in full by domestic output, which has to be supplemented by imports of pyrites.

The pyrites industry is constantly endeavouring to increase its output, to keep pace with the rising sulphur demand for sulphuric acid manufacture. The expanding use of crude sulphur ore concentrate appears to provide an economical raw material, which particularly in Sicily may well supplant pyrites. The continued rise in fertiliser requirements, boosted by the Government's agricultural programme, and the expansion of Italy's industrial activity, points to the needs of the acid industry rising to over 800,000 tons sulphur by 1958.

Non-Acid Uses

The distribution of elemental sulphur use in Italy during the period 1950-1955 is as follows:—

	Rayon (CS_2)	*Pulp (SO_2)*	*Agriculture*	*Other*	*Total*
	Thousand Tons				
1950 ...	27.0	12.0	40.0	9.0	88.0
1951 ...	52.7	16.6	54.8	24.5	148.6
1952 ...	15.0	9.7	47.4	7.2	79.3
1953 ...	30.7	14.4	29.9	7.0	82.0
1954 ...	36.8	14.5	40.3	15.7	107.3
1955 ...	40.2	15.8	46.2	5.0	107.2

The viscose rayon industry wholly represented by the *Societa Nazionale Industria Applicazione (S.N.I.A.) Viscosa*, one of the largest manufacturers of viscose rayon filament and staple fibre in Europe, accounts for about 40% of total elemental sulphur usage in Italy.

The company's CS_2 manufacturing plants, situated at Veneria Reale (Turin), Collestatte (Umbria) and Varedo (Lombardy) supply the entire requirements of its eleven viscose plants but all sulphuric acid requirements are obtained from Montecatini. The following table shows details of activities in viscose manufacture:—

	Production of (000 tons)			
Year	*CS_2*	*RAYON*		
		Filament	*Staple*	*Waste*	*Total*
1950 ...	37.7	46.2	52.4	4.1	102.7
1951 ...	45.3	60.1	64.4	4.6	129.1
1952 ...	25.8	36.3	36.3	2.6	75.2
1953 ...	35.4	47.4	52.8	3.7	109.9
1954 ...	37.4	55.9	61.6	4.4	121.9
1955 ...	38.0	56.1	67.0	4.2	127.3

Sulphur for agricultural purposes is consumed by a substantial number of small to medium sized sulphur refiners and grinders, who supply both home and export markets.

The rubber industry, represented by *Pirelli* — the largest producer — *Michelin*, *C.E.A.T.*, and *Hutchinson*, together with the footwear industry, consume about 2,000 tons sulphur annually.

Sulphur consumption in the manufacture of sulphite, etc., amounts to 4,500-5,000 tons annually.

Sulphuric Acid

Italy is the third largest acid producer in Europe. Production of sulphuric acid in 1955 amounting to 1,900,000 tons, compared with 1,817,000 tons in 1954, was exceeded only in the U.K. and Western Germany.

Due to the exceptional expansion of the organic chemicals sector of the industry over the past five years, the index (1950—100) for sulphuric acid output of 145 in 1954 compares unfavourably with that for the whole chemical industry of 191 in 1954, but continues to approximate industrial activity as a whole.

Acid production during the period 1950-1955 was as follows:—

	Contact	*Chamber*	*Total*
	000 tons (100% H_2SO_4)		
1938	157	919	1,076
1950	412	864	1,276
1951	523	942	1,465
1952	552	953	1,505
1953	581	1,020	1,601
1954	661	1,174	1,835
1955	670*	1,230*	1,900

*Estimate.

Due to the large proportion of acid used in fertiliser manufacture, about two-thirds of the sulphuric acid output continues to be based on the chamber process, although at most plants modern tower converters have been installed. Comparative data of consumption for the past five years are as follows:—

	1953	*1954*	*1955*
	000 tons (100% H_2SO_4)		
Fertiliser	1,244	1,450	1,460
Textiles (incl. Rayon) ...	130	172	207
Metallurgy	31	30	41
Other	170	160	190
	1,575	1,812	1,898

The dominant position of *Montecatini* as pyrites producer is reflected in the acid sector of industry. Of a total of about 90 sulphuric acid plants, 58 are owned by Montecatini and associated companies whose output in 1955 of 1,290,000 tons (100% H_2SO_4) represented 68% of Italian production, compared with 1,238,000 tons in 1954 when Montecatini's share accounted for 67.5% of total output.

During recent years Montecatini has carried out extensive reconstruction and expansion on most fertiliser/sulphuric acid plants mainly by addition of towers which increased the capacity of the old chamber installations. In 1955 work on eleven such plants was completed while at the same time new construction of several contact sulphuric acid plants was progressing. Since 1945 a total of five have been built.

During the past year construction work on the contact plant at Linate was started, and the important acid/fertiliser project of the subsidiary *Soc. Akragas* at Porto Empodocle was successfully completed.

The sulphuric acid installation of this plant is of particular interest since it is based

on the use of crude sulphur ores containing 18-32% free sulphur, 2-3% sulfate sulphur. In view of the higher rate of combustion, but lower calorific value of this material compared with pyrites, roasting furnaces were designed on a smaller scale, only 4.50 metres, but with a large combustion chamber divided into only two hearths to permit intensive roasting. Three furnaces each with a capacity of 7-10 tons sulphur, i.e., 28-40 tons sulphur ore per twenty-four hours, provide the roaster gas for the contact convertor which has a daily capacity of 70 tons (100% H_2SO_4).

Sulphuric Acid Plant of Soc. Akragas

A notable feature of the plant is the highly efficient raw material handling equipment which in view of the large quantities of sulphur ore, residual ash and, of course, all other fertiliser materials, notably phosphate rock, is essential to ensure economic operation. The plant, favourably located both in respect of raw materials and export markets, has an output capacity of about 25,000 tons concentrated fertiliser, notably triple (47-49% P_2O_5) and ammoniated superphosphate (15-16% N_2, 30-32% P_2O_5).

Practically all other important manufacturers of sulphuric acid are also prominently engaged in fertiliser manufacture. Operating one or more acid plants each, there are several Farmers Co-operatives, notably at Piacenza, Cerea and Cremona, Soresina, Vercelli, Novara, Portogruero, S. Elpidio, etc., and a small number of independent fertiliser producers such as *S.A. Prodotti Chimica della Campania* at Caserta, *Chimici e Derivati Affini S.p.a.*, Bolzano, *Bombrini Parodi Defino* of Rome, *Industrie Chimiche Dr. Baslini* of Milan, *Marchi* of Florence, etc.

Pyrites Residues

At the current level of activity of the sulphuric acid industry the annual cinders outfall amounts to about 800,000 tons. At least 75% of this tonnage are residues of Maremma pyrites which, containing about 58-60% Fe, are practically free from any deleterious impurities. The Italian Iron and Steel Industry whose iron ore requirements cannot adequately be met from indigenous resources, values this supplementary source of iron supply, and consumes up to 800,000 tons residues annually. Due to the special properties which these residues impart to the resultant pig iron they are actively sought by iron masters in Germany and Austria. Whereas due to high sea freights deliveries to the former have practically come to a standstill during the past two years, regular supplies of at least 100,000 tons per annum, but subject to availability as much as 400,000 tons per annum are delivered to the Ver. Oest. Stahlwerke, Linz.

Treatment of cupreous pyrites residues takes place at Montecatini's copper extraction plant at Porto Marghera. Due to the inadequacy of domestic supplies of this grade of ore the bulk of suitable residues originates from imported pyrites, in particular cupreous ore supplied by the Cyprus Mines Corporation.

The treatment plant which was originally established in the 'twenties has been extensively modernised after sustaining considerable war damage. It has an intake capacity of 200,000 tons per annum residues, which yield copper precipitate and purple ore, suitable as blast furnace charge. In 1955 output amounted to 100,000 tons iron (100%), 4,231 tons copper (100%), the latter almost exclusively used in the manufacture of copper sulphate.

Elemental Sulphur Trade

The mainstay of the Italian elemental sulphur industry remains its ability to sell a major portion of its output on export markets. Prior to World War II a series of agreements with U.S. producers enabled the industry to sell profitably over 300,000 tons sulphur annually, of which up to 10% were placed in the U.K., a traditional market for Italian sulphur. Since the resumption of exports last autumn with the aid of Government subsidies, the sulphur trade policy is of necessity centred on markets

where Italian sulphur enjoys a freight advantage, and it is the declared policy of E.Z.I. to sell in such selected markets competitively with U.S. and Mexican suppliers. Under present freight market conditions the range of Italian exports would seem to be limited to Mediterranean and Central European, notably Iron Curtain, countries where there is an outlet for up to 100,000-150,000 tons annually.

Trade with Iron Curtain countries offers Italian sulphur a large potential outlet and negotiations with U.S.S.R. for some 50,000 tons are still in progress. Of the various qualities of fused sulphur the export trade is concerned mainly with Gialla Inferiore (min. 99% S) and Buona Sicilia (min. 98% S), whilst Gialla Superiore (min. 99.5% S) is largely taken up by domestic consumers. With the aid of an export subsidy of up to Lire 10,000 per metric ton the export price of Italian sulphur has been lowered to about Lire 23,000 per metric ton (£13 7s. per ton) f.o.b. The principal shipping ports are Licata and Porto Empodocle where vessels of up to 5,000 tons can be accommodated, although loading is generally done by lighter. A large proportion of the Mediterranean trade is, however, effected in much smaller vessels down to 500 tons, which can use the many small ports where E.Z.I. sulphur warehouses are situated. In 1955 exports of fused sulphur amounted to 46,768 tons compared with 526 tons in 1954. In addition domestic refineries exported refined sulphur of various grades at a level similar to 1954, when about 8,000 tons were exported, as against export shipments of up to 28,000 tons prior to 1952.

The domestic market does not benefit from the Government subsidies and the controlled sales price is at present, following a reduction of about Lire 8,000, Lire 47,000-48,000 per metric ton. Consuming industries are thus placed at a considerable disadvantage and it is believed that strong representation for an adjustment of domestic prices of sulphur are about to be made.

Pyrites Trade

The foreign trade in Italian pyrites has been governed since the war largely by consideration of Government trade policy and the desire of Montecatini to maintain supplies to established foreign customers. Among these Switzerland, Austria and Holland are the most prominent, the last named country in view of the major interest of Montecatini in the Sluiskyl works of Cie. Neerlandaise de l'Azote. Exports to Czechoslovakia, however, whose pulp industry used to be a regular user of Italian pyrites practically ceased since 1949 following the political changes in that country.

The principal export port is Follonica where Montecatini have modern loading instal-

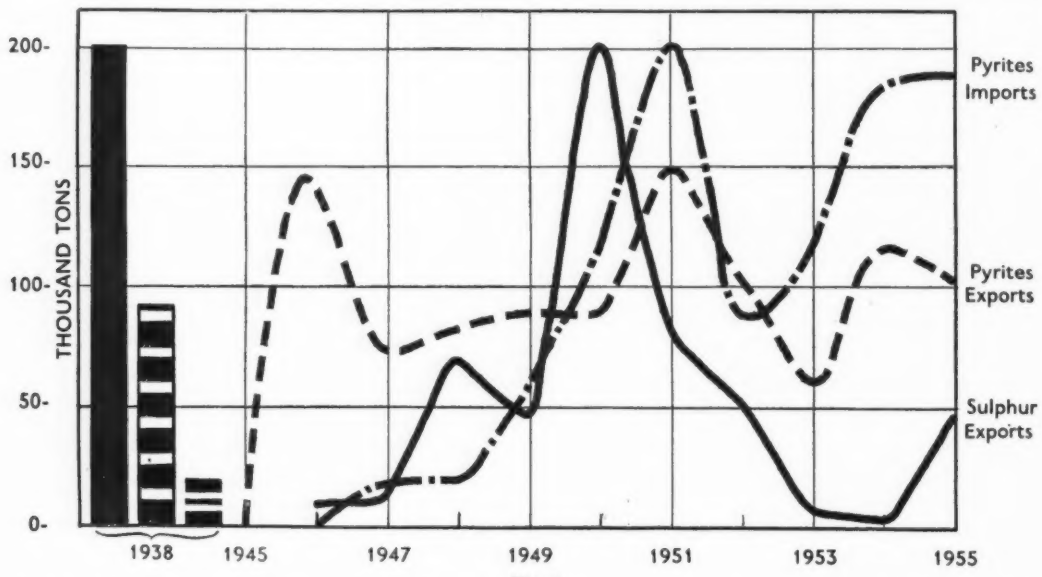


Fig. 4.

lations. A large proportion of exports by Montecatini and all those effected by Marchi, the latter mainly to Switzerland, move by rail through Chiasso or the Brenner pass and are sold on the basis of f.o.r. frontier stations. The export values of pyrites which in 1955 was Lire 15,400 per ton (£8 16s.) does not give a valid comparison with pyrites from other sources. Nevertheless, even if due allowance is made for internal transport charges Italian pyrites, due to their superior quality, command a premium of at least 10%. In the first eleven months of 1955 pyrites exports amounted to 96,365 tons compared with 116,416 tons for the year 1954*.

The need for pyrites imports is governed by two aspects:—

(i) The supplementary supply of sulphur to balance domestic requirements combined with the need for additional supplies of cupreous pyrites. Imports from Cyprus and in recent years from Cuba yield the necessary supplies of cupreous cinders for the adequate operation of the extraction plant at Porto Marghera thus providing essential copper economically.

(ii) Trade considerations. Most of the balance of Italy's pyrites imports originates from Spain and Greece and these supplies are primarily determined by the similarity of these countries' economies to that of Italy, which narrows the field of exchangeable commodities, so that the volume of pyrites imports correspondingly opens disposal facilities for Italian products.

Imports of pyrites during the first eleven months of 1955 totalled 188,893 tons compared with 184,304 tons during 1954*.

Conclusion

The outstanding feature of the Italian sulphur industry is the contrasting development of its two principal branches—pyrites, based almost entirely on the domestic sulphuric acid industry, and elemental sulphur, predominantly dependent for its welfare on export markets. The main effects of this rigid division in recent years were a dearth of exportable pyrites—potentially high revenue earners—and the lack of an adequate domestic outlet for elemental sulphur, production of which, despite its failure to compete in world markets, was maintained largely for political reasons owing to the impact that reduced employment would have on the economy of Sicily. The increasing use of sulphur ore in sulphuric acid manufacture is therefore significant, as apart from providing the acid industry with an economic indigenous source of sulphur, thus probably creating a greater exportable surplus of pyrites, it should add stability to the sulphur mining industry which is at present at a critical stage in its long and varied history.

The Central Government's direct financial aid in the form of sulphur export and production subsidies allows the industry no more than a breathing space in which to take advantage of the various legislative provisions by the Central and Regional Governments to promote the rationalisation and modernisation of its operations. On the technical side, and particularly in respect of ore refining, the development of economic refining processes permitting high recoveries of sulphur, has gone some way towards overcoming one of the major causes of high production costs. In this field, Italian scientists, notably the technical staff of E.Z.I., the Centro Sperimentale per l'Industria Mineraria under Professor Aprile, Ing. Masobello, Professor Roma and Ing. Gualtieri have in recent years made important contributions.

The principal obstacle, however, which not only detracts from the full effect of the installation of efficient mining and refining plant but primarily prevents the closure of uneconomic mines which do not warrant re-equipment, is social and political. With the increasing industrialisation of Central and Southern Italy and notably of Sicily, where new oil and fertiliser industries promise to provide rising employment, a gradual reduction of redundant sulphur mining labour may be achieved. In the meantime co-operative action by groups of small producers who individually could neither afford nor support modern plant is being encouraged by appropriate legislation.

The realistic trade policy of E.Z.I. during the past months has resulted in a satisfactory resumption of exports, which, taking up the industry's export surplus, has enabled E.Z.I. to reduce the stockpile to 332,000 tons at the end of January 1956.

*For further details see Statistical Appendix.

Whereas no early solution to the problems is likely to be achieved, and Government subsidies may have to be increased, as competition in world sulphur markets becomes fiercer during the next year, the outlook is now more promising than twelve months ago. Nevertheless, as elemental sulphur output over the next three-five years is foreseen at a rate of about 200,000 tons per annum, a more realistic approach to rapid rationalisation and modernisation is required if Italian sulphur is ever to compete on level terms on the world market.

As long as the real cost of producing elemental sulphur exceeds its sales value and while Maremma pyrites, due to their exceptional residues value, are in demand by most sulphuric acid makers in Europe, a closer integration between the two sections of the sulphur industry appears desirable. The prominent part played by Montecatini in the production and the use of sulphur in various forms holds promise that a correct balance will be established to the greater advantage of the individual sections of the Italian sulphur industry and the national economy as a whole.

We are indebted to Ente Zolfi Italiani, Montecatini S.p.A., S.N.I.A.-Viscosa and S.M.I., Sicula Mineraria for the information and photographs which they kindly placed at our disposal.

Prices and Trends

Prices

The two price structure that evolved since the advent of Mexican sulphur supplies on world markets was significantly thrown into relief when early in February the Freeport Sulphur Company decided to abandon the differential between export and domestic prices. The new prices applicable to export shipments from Port Sulphur made after midnight on 13th February are as follows :—

Bright sulphur ...	...	$28 per ton f.o.b.
Off colour sulphur	...	$27 per ton f.o.b.

The new export prices, representing a reduction of $3 per ton, on the respective grades, constitute a departure from the common price policy of the U.S. sulphur producers whereby, irrespective of quality premiums imposed at any time by bright sulphur producers such as Jefferson Lake Sulphur Company and the Standard Sulphur Company, domestic sulphur users were given the benefit of lower prices.

It is significant that it was the Freeport Sulphur Company who in 1938 terminated a twelve year period of price stability by reducing prices, then by $2 per ton, an action which the other U.S. producers were obliged to emulate. This time there are as yet no indications that the other producers, notably Texas Gulf Sulphur or Jefferson Lake Sulphur, intend to abandon the differential between domestic and export prices. It should, however, be borne in mind that their output, with the exception of about 20% of Texas Gulf Sulphur's, is bright, whereas, now that Hoskins Mound is exhausted and closed, practically the entire output of Freeport is off-colour, although, according to demand, some of it is made bright by suitable and not inexpensive treatment, notably filtering. The price reduction occurs at a time of rising labour and material costs in the U.S.A., which under stronger market conditions might have prompted sulphur producers to make an upward adjustment of prices. The reaction of domestic consumers, who are faced with similar cost increases, as well as an imminent rise of about 6% in rail freights, to the loss of a long-enjoyed position of privilege yet remains to be seen.

As the result of Freeport's decision the company's export price for dark sulphur is now only 50 cents higher than that of the principal supplier of Mexican sulphur, the Pan American Sulphur Company. There has been no change in the price of Mexican sulphur, the bulk of which is offered at $26.50 f.o.b.

The Ente Zolfi Italiani is pursuing the competitive price policy which was initiated last autumn, when the Italian Government authorised the payment of a subsidy to make the re-entry of Italian sulphur into export markets posible and the volume of sales in countries where Italian sulphur enjoys a freight advantage over U.S. and Mexican supplies is reported to be growing.

The bulk of export sales is in the form of Gialla Inferiore (min. 99% sulphur) and Buona Sicilia (min. 98%) which, subject to any special discounts which may be applied in

certain markets, is offered at Lire 23,000-24,000 per metric ton (£13 7s.-£13 19s. per ton) f.o.b. Sicilian ports. As Ente Zolfi aims to offer a tangible price advantage to prospective buyers in selected markets, these quotations are likely to weaken under the intensified competition, although the limit of the present subsidy does not allow E.Z.I. much margin.

There has been no change in the effective price of Chilean sulphur, which is exported at about U.S. $20 per ton f.o.b. with the aid of compensating commodity imports. Although importers margins have narrowed due to the further weakening of world prices of sulphur, the volume commodity transactions and sulphur demand, notably from W. European countries and Scandinavia, is more than adequate to give an outlet for Chile's entire export surplus.

The following table shows a comparison of prices of sulphur or different origin. F.o.b. prices and freights are based on recent quotations :

	f.o.b. Country of origin.	*Freight to‡ U.K.*	*per ton c.i.f. U.K.*
U.S.A. Freeport Sulphur Co.	$27-28	95/-	£14⅜-14¾
Others	$29.50-31	95/-	£15¼-15¾
Mexico	$25-26.50	95/-	£13⅝-14¼
Italy/Sicily	L.23,000	62/6	£16½
Chile	U.S. $18-22	115/-	£12⅝-13⅝
Japan	U.S. $34*	112/6	£17¾
Ecuador	U.S. $42	115/-	£20¾
Canada	$20 ex-works	112/6	£19½

Pyrites

As anticipated, prices of European pyrites for delivery 1st half 1956 have remained unchanged, at a level of £4 15s.-£5 5s. per metric ton f.o.b. The pressure by Continental pyrites users for a price reduction eased following an improvement of over 10% in the value of pyrites residues which now amount to about £3 to £3 5s. per ton of iron pyrites.

In Spain the Government recently authorised an increase of salaries and wages which, being introduced in two stages, will total 27½% of present basic wage rates and social security payments. It is expected that in consequence the Spanish pyrites producers may be forced to raise their prices, since the Spanish Government is likely to resist the adjustment of existing exchange rates applicable to pyrites exports as a means of greater Peseta revenue. In this event the European producers' desire to maintain a uniform price structure may lead to all-round price increases which would of course further aggravate the competitive position of pyrites in relation to elemental sulphur.

Freights

The substantial revival in demand for grain vessels clashing with demand in North Atlantic coal trade, points to renewed firmness in sulphur freight rates from the Gulf of Mexico. Sulphur freights to India will rise by $2.50 as from 1st May, following the decision of the U.S. Eastbound Shipping conference to give effect to cumulative increases in cost. Pyrites freights to the U.K. and Continent for prompt shipments tend to be weak; for late April/May lay days, however, the position is firm and rising from the current indication of 35/- Huelva to Continental ports.

Supplies

Production in the U.S.A. of Frasch and recovered sulphur is being maintained at the high level of the closing months of last year to meet strong domestic demand primarily from the sulphuric acid industry, which is stimulated by the large volume of acid used in rayon, steel and pigments manufacture, and the needs of petroleum and alcohol refiners. The seasonally adjusted index of industrial products stood at 143 in January and February—ten points higher than one year ago. This demand is being met without difficulty, and individual producers are also strongly promoting their export sales.

The pressure of Mexican sulphur supplies is increasing. The volume of stocks at the

‡Based on bulk cargoes of 5,000-6,000 tons on the usual sulphur terms of chartering.
*Calculated to basis of sales to Australia.

end of February of about 450,000 tons is rising rapidly, notwithstanding the recent reduction in output by Mexican Gulf Sulphur Corporation, as Pan-American Sulphur Company is now reported to be producing at the rate of $\frac{3}{4}$ million tons per annum.

As the result of rising export sales from Italy, current output arising at the rate of about 200,000 tons per annum, is reported to be moving satisfactorily, but by the end of 1955 the stockpile had only been reduced to 336,600 tons.

In Chile, an excessive volume of export commitments still threaten to keep the domestic market short of supplies. Estimated at about 60,000 tons per annum, production is falling short of the anticipated level, and there is little prospect of a substantial increase before the onset of the winter season.

The supply position in Japan remains critical, and with domestic supplies inadequate to meet the rising needs, primarily of the pulp and rayon industries, negotiations for the import up to 16,000 tons U.S. or Mexican sulphur are reported to be in progress.

Supplies of Scandinavian and Continental recovered sulphur supplies appear to be fully committed to the domestic industries, and, in the case of Norway, to established foreign customers. No offers are reported.

Production in Turkey during 1955 of about 25,000 tons substantially exceeds current domestic requirements. Due to the high cost of production, outlet appears to be limited to iron-curtain countries.

Pyrites

Production in 1955 by the principal European producers generally increased. In Spain output amounted to 2.05 million tons pyrites, 7½% more than in 1954, while Cypriot production of cupreous and iron pyrites totalled 144,000 tons and 817,000 tons respectively, an aggregate increase of about 22%. Exports, stimulated by the high level of consumption, notably in Germany and Holland, also increased, though at a lower rate than output. Due to their good quality and favourable price comparison, pyrites exports from Cyprus showed by far the greatest advance of 11%.

Seasonally high sulphuric acid requirements, notably for fertilizer manufacture, are sustaining the pyrites demand on the Continent, although in the United Kingdom the impact of cheaper raw materials, notably elemental sulphur and anhydrite, has already resulted in a substantial decrease in pyrites requirements. Supplies of European pyrites are ample, and increasing tonnages of competitive shipments of Cuban and Canadian pyrites are seeking an outlet in Europe.

Summary

On the basis of incomplete data it appears that the free world supply position in 1955 was as follows:—

	Production	*Consumption*
	Million Tons Sulphur	
Elemental sulphur ...	7.5	7.1
Pyrites	5.0	5.0
Other	1.7	1.7
	14.2	13.8

Compared with 1954, total sulphur production appears to have increased, as anticipated, by about 6%, as the result of the significant expansion of the U.S. and Mexican Frasch sulphur output. Consumption increased by 7%, almost entirely due to the sustained high level of U.S. domestic demand, accentuated by a world-wide rise in elemental sulphur usage, and in Europe by the high level of pyrites consumption.

With elemental sulphur stocks outside the U.S.A. of over 800,000 tons, and the continued high level production of Frasch sulphur, the supply position is very favourable, and, in particular, in export markets, competition in 1956 between U.S., Mexican and Italian suppliers promises to be fierce. While the main importing countries are making increasing use of indigenous resources, notably by way of sulphur recovery, the weight of low-cost Frasch sulphur supplies is expected to affect pyrites usage in markets where the values of residues cannot be fully realised either due to lack of, or excessive distance from, suitable outlets. Looking further ahead, the growing exploitation of sulphur resources in natural gas, promises to make Western Canada a major source of elemental sulphur supply, in spite of its adverse location in relation to principal markets. In the established area of supply—the Gulf of Mexico—off-shore sulphur producers appear to await a favourable development of the market to start exploitation of sulphur domes.

UNITED STATES SULPHUR

Native Sulphur

Production of Frasch sulphur in 1955 amounted to 5,743,344 tons, the highest annual total on record, exceeding the peak output of 1954 by 227,800 tons (4%). Production which, during the first six months of the year, had been restricted to an annual rate of only 5.2 million tons, spectacularly rose in the second half-year to an annual rate of 6.3 million tons, primarily as the result of peak production during the last quarter of 1,656,764 tons which culminated in the December output of 575,144 tons.

Individual producers' output based on preliminary data were as follows:—

	1955	*1954*	*Change*
	000 Tons		*%*
Texas Gulf Sulphur Company	2,952	2,769	+ 6½
Freeport Sulphur Company	2,078	2,071	+ ½
Jefferson Lake Sulphur Company	485	433	+10½
Duval Sulphur & Potash Company	169	169	—
Standard Sulphur Company	59	74	−20
	5,743	5,516	+ 4

Texas Gulf Sulphur Company increased output at all three domes, Boling Dome's contribution amounting to about 2¼ million tons. The start of operations at the Freeport Sulphur Company's new Chacahoula dome in February, 1955, partly compensated for the loss resulting from the closure in May of operations at Hoskins Mound. Satisfactory production at the company's other domes, notably Garden Island Bay, resulted in a slight increase in the aggregate output. Jefferson Lake Sulphur Company continued their vigorous expansion of production which over the past two years has increased by about 25%.

Production of native sulphur from surface deposits is believed to have contributed about 60,000 tons sulphur. The bulk originated from the Leviathan mine of the Anaconda Copper Mining Company, which uses crude ore containing 25-30% sulphur, in the manufacture of sulphuric acid. Mining operations started at Sulphurdale, Utah, to supply the anticipated requirements of the new refining plant of the American Sulphur & Refining Company's, operation of which appears, however, to have been temporarily deferred.

Apparent sales of Frasch sulphur amounting to 5,790,166 tons reached the highest level on record, and were 480,000 tons (9%) greater than in 1954, the previous peak year. The dominant factor in the high level of sales was the expansion of domestic sulphur requirements, as export sales, though impressive at 1,595,423 tons, were about 50,000 tons (3%) lower than the record total shipped in 1954. Supplies of Frasch sulphur to domestic consumers were augmented by imports from Mexico, which in 1955 totalled 60,000 tons. Total domestic Frasch sulphur consumption is estimated to have reached about 4¼ million tons, an increase of 12½% over 1954.

The high level of production during the second half of the year, notably the last quarter, reversed the earlier trend in the movement of stocks, and at the end of 1955 these amounted to 3,181,198 tons, a reduction of only 46,800 tons (1½%) of producers' stocks held at the beginning of the year.

Recovered Sulphur

Production of recovered sulphur in 1955 amounted to 401,650 tons, the highest on record, and 12½% greater than output in 1954, the previous peak year. Output was consistently high, and rose towards the end of the year, as new recovery facilities came into operation. The highest monthly total was achieved in October, when 36,100 tons sulphur were recovered from natural and oil refinery gases. New installations converting H_2S extracted from natural sour gas included the plants of Jefferson Lake Sulphur Company at Manderson, Wyoming; J. L. Parker Company, Penwell, Texas; Signal Oil & Gas Company, and J. L. Parker Company at 14-Mile Field, Wyoming. Amongst oil refiners new sulphur recovery installations started operating at the refineries of Gulf Chemical Company, Girard

Point, Pa., Sun Oil Company, Marcus Hook, Pa. and Union Oil Company, Santa Maria, Calif.

Apparent sales in 1955 totalled 400,125 tons, an increase of 12½% compared with 1954, the previous peak year. Supplies of recovered sulphur are wholly taken up by domestic users, whose requisitions in the late autumn, contrary to earlier years, do not appear to have been subject to heavy seasonal fluctuations. Changes in stocks over the year were slight, and the tonnage of 110,591 at the end of the year was about 1% greater than on 1st January.

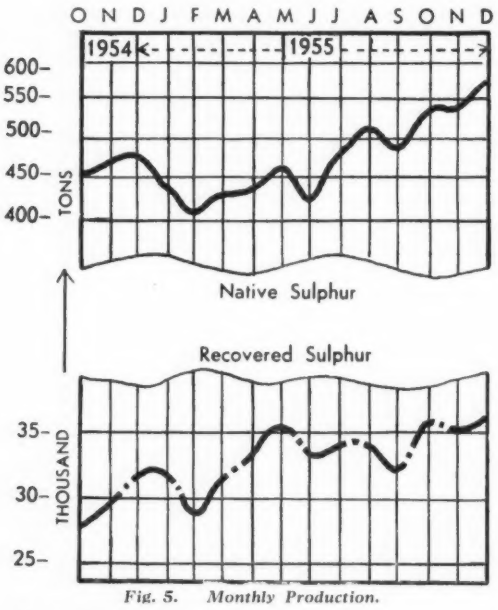


Fig. 5. Monthly Production.

Other Sulphurous Raw Materials

It is estimated that production of sulphur in other forms amounted to 810,000 tons, an increase of 2½% compared with 1954. The total, which excludes the sulphur equivalent of recovered sludge acid, is believed to be made up as follows:—

	1955	*1954**
	(000 tons)	
Sulphur in pyrites	400	405
Sulphur in smelter gases	315	300
Sulphur in by-product acid from H_2S and liquid sulphur dioxide	95	85
	810	790

*Amended.

The prinicpal addition to supplies was made by the Rico Argentine Mining Company, who as from September 1955 has been using pyritic tailings from lead zinc ore flotation, in their new sulphuric acid plant at Rico, Colorado.

Consumption

The U.S. heavy chemical industry experienced a record year as free consumer spending and liberal extension of credit boosted production in steel, automobile, rayon, pulp, rubber and most other industries. Sulphuric acid output rose to a peak of 15.7 million short tons, an increase of 12% compared with 1954, of which about 14.9 million tons was virgin acid. New installations during this year raised the rated capacity of sulphuric acid plants to 18.45 million short tons of virgin acid.

Sulphur requirements for non-acid uses similarly expanded and are estimated to have totalled 1.1 million tons, made up as follows:

	1955	*1954*
	(000 tons)	
Pulp	430	400
CS_2	220	200
Insecticides	120	100
Chemicals, Dyes	100	90
Rubber	85	75
Other	145	155
	1,100	1,000

Domestic sulphur supplies were augmented by about 185,000 tons imported in the form of Canadian pyrites and Mexican Frasch sulphur.

The salient points in the developments of the U.S. sulphur industry are thought to be as follows:—

(a) Production of Frasch and recovered sulphur in 1955 of 6,144,994 tons, an increase of 272,000 tons (4½%) over 1954, was the highest on record. Sulphur supplies in other forms and imports amounted to about 1 million tons.

(b) Apparent sales of Frasch and recovered sulphur amounted to 6,190,291 tons, an increase of 525,000 tons (9½%) over 1954 the previous peak year. The increase does not fully reflect the expansion of domestic requirements as sulphur exports receded slightly to 1.6 million tons and supplies at the disposal of industry were augmented by imports from Mexico of about 60,000 tons.

Domestic consumption is estimated to have totalled about 5.6 million tons of which 4.7 million tons was in the form of elemental sulphur, and the balance sulphur in pyrites, smelter gases, etc.

(c) Producers' stocks of Frasch and recovered sulphur at the end of 1955 amounted to 3,291,789 tons, a decrease of 45,000 tons (1½%) during the year. This level of stocks is estimated to represent about 8½ months supply at current rates of consumption.

Outlook for 1956

Industrial activity in the U.S.A. and the chemical industry in particular is expected to exceed the level achieved in 1955 by 3-4%. Indications point to a higher level of output and sales during the first six months at about 4-5% above 1955 accompanied by a moderate increase of inventories. New investment in the chemical industry is expected to amount to $550 million in the first half year and $1,125 million for the whole of 1956. The outlook for the sulphur using industries reflects the general industrial picture, though there are indications that the demands for sulphur are rising more rapidly than industrial and agricultural activities in general. Major sulphuric acid plant projects due for completion this year include the following :—

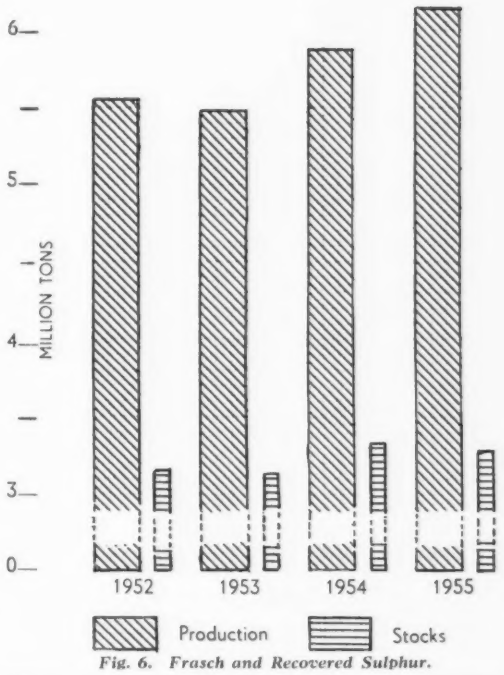


Fig. 6. Frasch and Recovered Sulphur.

Company	*Location*	*Remarks*
Allied Chemical & Dye Corporation, General Chemical Division	St. Louis, Illinois	—
American Cyanamid Co.	Joliet, Illinois	Annual capacity 50,000 tons
Consolidated Chemical Industries	Le Moyne, Alabama	Annual capacity 165,000 tons
Du Pont Co.	Ohio	—
National Farmers' Union Resources Corporation	Rich County, Utah	Cost $5 million
Northern Chemical Industries Inc.	Searsport, Maine	Annual capacity 45,000 tons Cost $600,000
Reichhold Chemicals Inc.	Tuscoloosa, Alabama	Annual capacity 33,000 tons
National Distillers Products Corp. U.S. Industrial Chemicals Co. Division	Tuscola, Illinois	Annual capacity 140,000 tons Cost $2 million

By the end of 1956 it is anticipated that rated capacity of acid plants will amount to 19.3 million short tons, an increase of 850,000 tons. New projects at present being initiated include in addition to facilities for virgin acid production, a number of acid sludge and pickle liquor treatment plants. Virgin acid output is expected to total 15.3 million short tons.

Among non-acid sulphur users the pulp industry, which is called on to meet its share of the constantly rising demand for paper, is expected to requisition up to 10% more sulphur than in 1955. Expansion of sulphur requirements for carbon disulphide and other chemicals is likely to be more moderate and sulphur use in rubber manufacture should at best be maintained at last year's level. It is estimated that domestic sulphur demand in 1956 will amount to 5.8-5.9 million tons, of which 4.9-5.0 million tons will be elemental sulphur.

To meet the requirements of the domestic market and to maintain export sales at last year's level of 1.6 million tons, producers of Frasch sulphur will have to rely on existing facilities as it is unlikely that additional dome capacity will be ready for operations. The Freeport Sulphur Co., having proved a substantial deposit at Lake Pelto off the Louisana coast under 6 feet of water, are now installing the necessary plant for its exploitation. The Humble Oil & Refining Co. have not yet decided whether to develop their

proved dome deposit in Block 16, and are progressing with their exploratory work on another dome in Block 18. Texas Gulf Sulphur are reported to have two domes, Lake Bullicamp and Fannett, under development and the Sulphur Exploration Company recently announced plans for the installation of a 600,000 gallon plant to exploit the High Island dome.

Recovered sulphur production, thanks to the further expansion of facilities, is expected to rise 11-12% to over 450,000 tons. Supplies to domestic users will be augmented by imports of Mexican Frasch sulphur which are expected to rise to at least 150,000 tons, possibly more, if under the increasingly competitive conditions of the market more domestic users decide to take advantage of the lower priced Mexican off-colour sulphur.

With the domestic market booming, U.S. sulphur producers face nevertheless increasingly competitive conditions. Rising costs of production have to be met wholly from the still ample profit margin, and in their endeavour to increase the volume of sales, the individual U.S. producers are faced with the decision, however distasteful, not only whether to follow the lead of the Freeport Sulphur Company in reducing export prices, but whether in order to attract a greater share of the domestic market it has become necessary to lower domestic prices, and re-establish, where applicable, the price differential enjoyed by domestic users.

In these considerations, the desirable rate of exploitation of many ageing domes will no doubt play a major part. In the light of anticipated domestic demand and export prospects it may be expected that production in 1956 will be maintained and may possibly exceed last year's record level.

FREEPORT SULPHUR COMPANY

THE 43rd Annual Report, presented by the Chairman, *Mr. John Hay Whitney,* and the President, *Mr. Langbourne M. Williams,* gives account of the company's sulphur and other mineral activities in 1955, which financially was the most successful year on record.

Sulphur

Production, which for the second year in succession exceeded 2 million tons, originated from six Frasch sulphur domes, augmented by a small quantity of recovered sulphur from the oil refinery gases at Eagle Point, New Jersey. On May 27th the company's oldest dome, Hoskins Mound, was closed after 32 years' continuous operation, longer than any other U.S. sulphur dome, having in this period yielded nearly 11 million tons sulphur. Operations started on 25th February 1955 at the

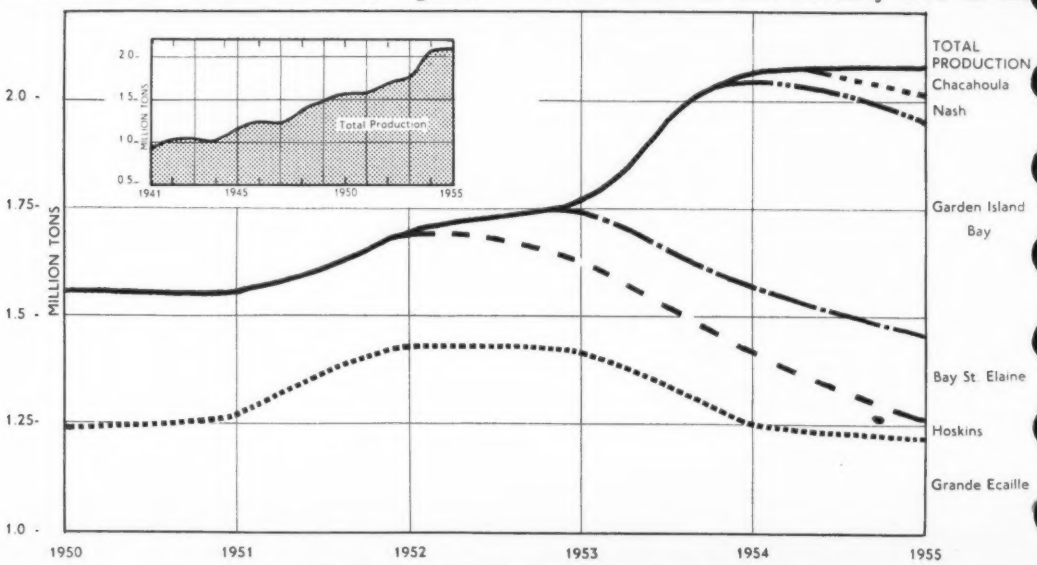


Fig. 7. Frasch Sulphur Production 1941-1955.

Port Sulphur: Loading installations for solid and liquid sulphur.

Chacahoula dome, near Thibodaux, Louisiana, 60 miles west of New Orleans, which, although a high cost producer, will compensate for the loss of output from Hoskins Mound. Grande Ecaille dome, having produced nearly 1¼ million tons, remained the company's largest producing property, followed by Garden Island Bay, where output was close on ½ million tons, and the two smaller domes, Bay St. Elaine and Nash.

Sulphur sales were the highest on record, yielding a gross revenue of over $63¼ million. To expedite shipment of solid and the increasing volume of liquid sulphur the dock facilities at Port Sulphur which handle the production of Grande Ecaille, Garden Island Bay and Bay St. Elaine, are being enlarged.

In February of this year the company decided to eliminate the existing differential between domestic and export prices* primarily with a view to strengthening its competitive position in export markets. At the same time it was noted that in spite of the increasing pressure of new supplies on world markets the company was able to maintain its long-established relations with virtually all customers.

Other Company Activities

Oil. In view of the size and continuing expansion of oil and gas operations which in 1955 resulted in the production of 1.63 million barrels crude oil, an increase of 45% over 1954, the company decided to form a new operating division, known as Freeport Oil Company, under the direction of Mr. H. C. Petersen.

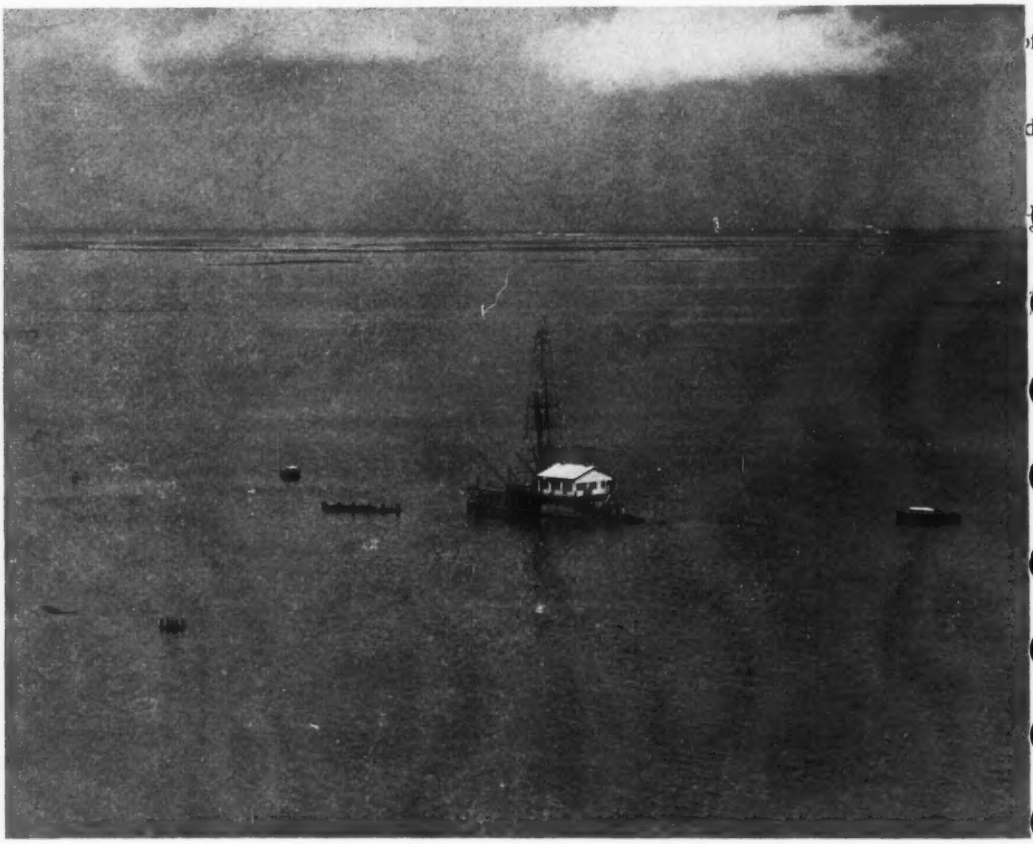
Nickel and Cobalt. The company's wholly owned subsidiary Nicaro Nickel Company, continued the remunerative supply of ore to the U.S. Government plant at Nicaro, Cuba. On successful completion of experimental work on a new ore treatment process it is planned to instal a commercial plant for the production of these two strategic metals.

*See also Prices and Trends page 18

Potash. Good progress is reported of the installation of mining and processing facilities at the Carlsbad, New Mexico, deposit of the National Potash Company, which is jointly owned by Freeport and Pittsburgh Consolidated Coal Company.

New Developments

Following the discovery of a substantial sulphur dome deposit at Lake Pelto 70 miles south-west of New Orleans, the company is now engaged in detailed engineering studies and plant site preparation which in view of the dome's location beneath 6-8 feet of water and separated from the open water of the Gulf of Mexico by only a narrow strip of land, presents many problems and may require considerable time before plant installation can be started. The size and character of the deposit make it an attractive addition to the company's sulphur reserves.



Floating Drilling Rig at Lake Pelto Dome.

Finance

The company's operating profit of $14,636,852, 10½% greater than in 1954, was the highest on record. After inclusion of other income and provision for Federal and State income taxes, the company's net income amounted to $12,401,058, an increase of over $2.3 million (23%) compared with the preceding year.

With earnings per share rising cents 76 to $4.96, the company increased its dividend payments in respect of 1955 to $2.62½ per share compared with $2.50 in 1954.

The outlook for 1956 points to a continued high level of activities. During the early part of this year output has already exceeded the rate achieved in 1955.

JEFFERSON LAKE SULPHUR COMPANY

According to the company's Annual Report and Balance Sheet, production and shipments of sulphur during 1955 were the highest on record; similarly dividend payments, the working capital and the net worth of the company have not previously been surpassed. Net profit before and after tax were, however, lower than the peak of 1954 and in his introductory message the President, Mr. Eugene H. Walet Jr., attributes this to four principal factors, namely the reduced sales price to meet competition, greater operating costs, 60% increase in depreciation charges and the inclusion in the 1954 results of a non-recurring revenue item.

Output in 1955 originated from the company's three sulphur domes—Long Point, (Fort Bend County, Texas) Clemens (Brazoria County, Texas) and Starks (Calcasieu Parish, Louisiana) all producing bright sulphur, exceeding 99.5% in purity, by the Frasch process—and the sulphur recovery plant at Manderson field, Wyoming, which reduces concentrated H_2S to elemental sulphur.

Details of production are as follows :—

	1955	*1954*	*1953*
Clements	124,000	96,100	98,500
Long Point ...	250,000	249,200	190,900
Starks	111,000	88,200	71,800
Manderson ...	15,000	—	—
	500,000	433,500	350,300

Total production of native and recovered sulphur in 1955 was 15% greater than in 1954. The recovery plant at Manderson which started operating early in March 1955 is rated at 130 tons sulphur per day. Owing to restricted supplies of hydrogen sulphide, which are drawn from the natural sour gas cleaning plant of Socony-Mobil and other oil companies, its operations were restricted to 40% of rated capacity. Initial storage of sulphur is in liquid form and it is then solidified into flakes on one of the company's flaking machines, facilitating quick shipment even under adverse weather conditions prevalent in Wyoming during the winter months.

Sales

Shipments and sales for the company's own account totalled 295,000 tons, 13% more than in 1954 and the largest quantity in the company's history. In addition about 115,000 tons were shipped for the account of Texas Gulf Sulphur Company. In view of the highly competitive state of the domestic and international sulphur market—export destinations include the United Kingdom, most European countries, Australasia, Philippines, India, Uruguay and the Argentine—the company reduced its prices to bring them into line with those of the other leading U.S. producers, i.e. $26.50 per ton ex mine for domestic sales and $31 per ton f.o.b. Gulf Port for export sales of bright sulphur.

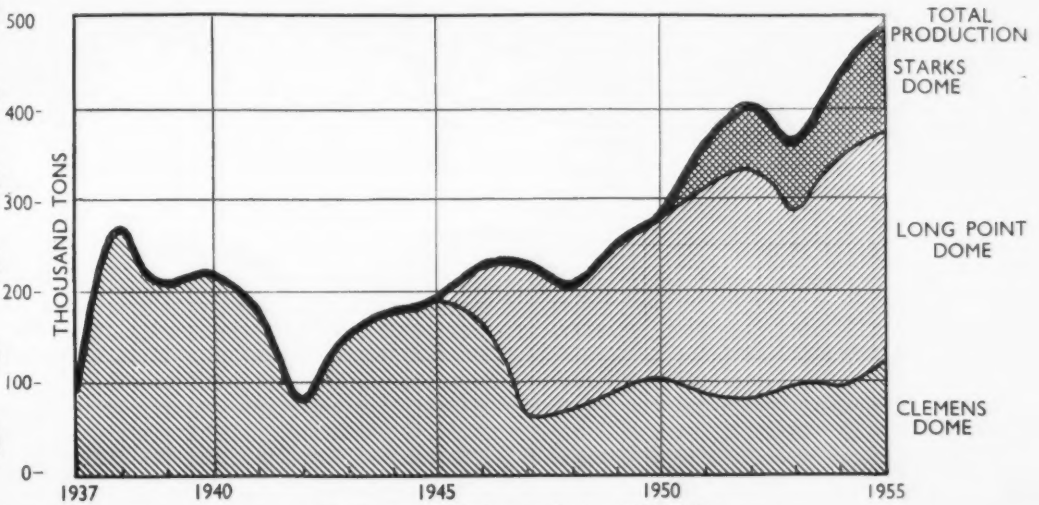


Fig. 8. Frasch Sulphur Production, 1937-1955.

Stocks and Reserves

On account of the excess of production over shipments, stocks at the various domes appear to have increased by over 90,000 tons, with the result that the inventory valuation of sulphur stocks increased by nearly 50%.

Exploration wells drilled on some of the company's operating properties encountered rich sulphur formations in hitherto unexplored areas and known reserves were thereby substantially increased.

Starks Dome.

Finance

The net operating profit for 1955 amounted to $2,562,754, a decrease of 8½% compared with 1954. In consequence and in view of the substantial non-recurring revenue item of the preceding year, net income before deduction of income tax was about $925,000 lower, and after payment of $567,000 for Federal and State Taxes, $1,711,189 was carried to earned surplus. Dividend payments on common shares were raised from $1.30 in 1954 to $1.60 after payment of $0.70 on preferred shares as previously.

Other Activities

The company's first commercial Rotasorber Plant, designed to process 40 million cubic feet of natural gas per day by dehydration and selective adsorbtion of condensable hydrocarbons—was completed at Bayou Sale gas field, Louisiana. Agreements for the installations of three more units have been concluded and negotiations for additional plants are under discussion. Apart from products recoverable by established processes, the Rotasorber process and plant permit the recovery of hydrocarbon liquid reserves, which are at present sold as gas as their recovery is not economical.

The company has acquired the Merichem Company whose activities in manufacture of cresylic acid and sodium sulphide, at the plant located on Green Bayou in the industrial area of Houston, are to be expanded in 1956 and 1957.

New Projects

Fertilizer Plant. The project for the erection of a sulphuric acid and triple superphosphate plant at Montpelier, S.E. Idaho, is being re-examined in the light of the latest developments including legislation affecting agriculture and fertilizer supply.

Sulphur Recovery. Negotiations for additional sour gas and the erection of other sulphur extraction plants in Canada and in the U.S.A. are being pursued.

Gas De-sulphurising process and plant. A pilot plant incorporating the Rotasorber process to extract H_2S from natural sour gas is ready for testing following the successful completion of laboratory tests. In view of the great saving in plant and operating costs this development holds much promise.

Sulphur Recovery Plant at Manderson, Wyoming.

Submerged water heating. Equipment combining a gas turbine and a submerged burner is about to be tested. Its application to heating salt water is of specific interest to Frasch plant operators, in particular in off-shore locations.

Exploration. Well drilling on a number of shallow sulphur domes in the Gulf coast area, where leasehold rights are being held and are being acquired, is foreseen during 1956.

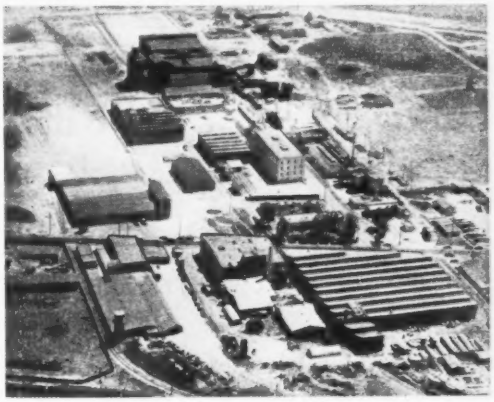
Conclusion

The outstanding achievements in 1955 of the third largest sulphur producer in the world are likely to be equalled if not surpassed during the current year, notwithstanding the strong competition which may, however, make it difficult to maintain the past level of financial results. The successful developments of the plant and process for the treatment of sour natural gas promise to secure the company an important place in this rapidly expanding sector of the sulphur industry.

STAUFFER CHEMICAL COMPANY

AMONGST the leading concerns in the chemical industry of the United States of America, the Stauffer Chemical Company is outstanding as the largest manufacturer of industrial and agricultural sulphur chemicals. These products and sulphuric acid, in the production of which Stauffer ranks amongst the top six U.S. producers, account for a large proportion of the Company's gross sales which in 1954 amounted to $82½ million. Since 1885 when John Stauffer founded the Company to operate a sulphuric acid plant in San Francisco, California, its activities have spread practically over the whole of the U.S.A. embracing to-day some forty-eight plants and establishments supported by a further ten plants operated by affiliated companies. The Company is the largest single producer of carbon disulphide in the U.S.A. It is estimated that its output in 1955 accounted for over one-third of total U.S. production of about 260,000 tons. Of the seven plants fully employed in the manufacture of this product, six are situated on the Eastern seaboard, the centre of the viscose rayon and transparent paper industries. The seventh plant, operated by the Wheeler, Stauffer, Reynolds Division at Richmond, California, is primarily concerned with the manufacture of carbon disulphide for agricultural use, as pesticides and insecticides. A wide range of specialised grades, has been developed, including a non-flammable product designed to permit safe fumigation of grain and other products. Use is made of a new process for the production of CS_2 which is licensed to Stauffer by the Food Machinery and Chemical Corporation. The process substitutes charcoal burners by reacting molten sulphur with methane. In view of the abundant supply of cheap methane—natural gas—in the U.S.A. the application of the process is increasing rapidly.

Eight plants, including those of affiliated companies, produce annually about ¾ million tons of sulphuric acid of all grades. Based on the contact process, their capacity ranges up to 1,000 tons acid (100% H_2SO_4) per day. Those in the East supply mainly the iron and steel industry, metal refiners, electroplating, oil refineries and rayon manufacturers, while the West coast plants look mainly to oil refineries, steel, fertiliser, agriculture and forest industries for an outlet. Superphosphate is manufactured at Los Angeles, San Francisco, and Tacoma, Washington. At Tacoma, a new liquid aluminium sulphate plant has started operation to supply the growing demand of the paper industry in the Puget Sound area. Established plants at Richmond, and North Portland, the latter supplying aluminium sulphate in liquid form, serve the paper industries of California and Oregon respectively.



Installations at Vernon, Los Angeles, California.

To meet the exacting specifications for sulphur in the rubber making industry three main brands have been evolved. "Tire" Brand and "Tube" Brand have vulcanising properties essentially the same, but differ with regard to fineness, flowing and dispersing properties. "Crystex"* insoluble sulphur has the special property of not blooming on uncured stocks and therefore finds wide application in the manufacture of white sidewall tyres and the retreading of tyres.

The numerous establishments of the Stauffer Agricultural Chemicals Division serve the agricultural areas on the West coast, in the South, South-West and mid-West. Various grades of dusting and wettable sulphurs are supplied to the local fruit and vegetable growers as a means of fungus and pest control, whilst free burning sulphur meets the needs of the canning and fruit drying industries. Coarse sulphur, applied directly to the ground,

*See Quarterly Bulletin No. 8, page 40.

to adjust the pH content of alkaline soils, is of special importance to the newly irrigated desert lands of California.

To meet rising demand the capacity of the factory at Orlando, Florida, was supplemented by a plant at Tampa, Florida, which came into production in June 1955. The plant has modern facilities for sulphur grinding, and is primarily concerned with the manufacture of insecticides.

The Company's sulphur requirements are primarily met in the form of Frasch sulphur, but increasing use is made of sulphur recovered from natural and oil refinery gases at plants favourably situated to such sources of supply. Acid plants in California, Texas, and Louisiana also make use of hydrogen sulphide arising at nearby oil refineries. It is estimated that the Stauffer Chemical Company uses annually about ½ million tons sulphur, i.e. about 10% of U.S. domestic use.

Over the past seven years the Company has put into operation ten new plants and executed a plant expansion programme covering about fifteen established works. Its emphasis on research and development, strengthened by the establishment of two new research laboratories, points to further expansion though not necessarily in the field of sulphur chemicals. Present expansion plans provide for the expenditure in 1956 of $15 million and conform with the once more rising trend of capital investment by the U.S. chemical industry.

SULPHUR IN MEXICO

Frasch Sulphur

IN 1955, the first complete year of operations of the Jaltipan dome, the *Pan-American Sulphur Company* produced 391,811 tons. In the closing months of the year production was increased substantially to a level of nearly 65,000 tons per month, and in January of this year production amounted to 66,000 tons.

Sales almost exclusively directed to export markets, amongst which the U.S.A. took up the largest tonnage, amounted to over 130,000 tons.

The company's expansion programme, which will result in a daily output of 3,000 tons sulphur as from July, is reported to be progressing satisfactorily. The installation of a filtering plant, based on activated clay, which will be capable of treating 1,000 tons off-colour sulphur per day is now on point of completion.

The operations of the *Mexican Gulf Sulphur Company* at San Cristobal which, in the late autumn had been successfully stepped up to 600 tons sulphur per day, suffered a setback as the result of the need to transfer operations to a different section of the dome.

The company is confident that the producing wells at the new locations will permit output to be raised speedily to satisfactory levels. Production in 1955 totalled 83,678 tons and sales to domestic and export markets are believed to have amounted to 80,000 tons.

The Gulf Sulphur Corporation, whose plant at Las Salinas dome was completed early this year, has deferred the start of steaming the dome, which was scheduled for February. Negotiations for the provision of new finance are reported to be in progress, and it may be expected that as soon as these are satisfactorily completed the dome will be activated.

The activities of the producers of Frasch and recovered sulphur in Mexico during 1955 are estimated as follows:—

	Frasch	*Recovered*	*Total*
		Tons	
Production	475,489	28,000	503,000
Exports Deliveries ...	207,000	—	207,000
Domestic Deliveries ...	10,000	25,000	35,000
Stocks, 1.1.55 ...	89,000	900	89,900
Stocks, 31.12.55 ...	347,000	3,000	350,000

Consumption

Construction work of six new sulphuric acid plants at a cost of $3 million, according to a recent report by the National Bank of Foreign Trade, is progressing favourably, and their aggregate output of 160 tons acid (100% H_2SO_4) per day will contribute to Mexican acid needs in the course of this year.

Shipping

In view of the dearth of adequate shipping particularly from Coatzacoalcos, Mexican shipping interests are planning to provide additional ships for the envisaged high level of sulphur exports. *International Cargo de Mexico, S.A.*, stated in January that six ships are to be purchased abroad at an initial expenditure of $1.5-2 million.

UNITED KINGDOM SULPHUR

U.K. Sulphur

Sulphur consumption in all forms during 1955*† amounted to 1,077,000 tons, an increase of 35,000 tons (3½%) compared with that in 1954, the previous peak year. The outstanding factor in last year's consumption pattern is the increase in anhydrite consumption for sulphuric acid manufacture, which together with the greater tonnage of elemental sulphur so consumed more than compensated for the lesser use of sulphur in pyrites and spent oxide.

Production of sulphurous raw materials estimated at 544,000 tons sulphur, was about 13% higher than in 1954, greater anhydrite output and recovery from oil refinery gases accounted for the bulk of the increase of about 60,000 tons sulphur.

The completion during 1955 of the third anhydrite acid project brought to a close the plant construction programme of 1951, which was primarily aimed at reducing the country's dependence on imported brimstone. In consequence and also in view of the availability of ample low cost brimstone supplies, H.M. Government decided to rescind the remaining restrictions on the use and imports of brimstone for sulphuric acid manufacture, and the industry thus starts 1956 free from controls for the first time since 1939.

As most of the increase in sulphur consumption and acid output were the result of greater use of indigenous raw materials, it was possible without adversely affecting stocks to reduce imports by about 9% of which pyrites declining by 15% accounted for three-quarters of the reduction. Nevertheless, the country's import bill for sulphurous raw materials increased fractionally (¼%) to £9.15 million due to the steep rise of freight costs.

Production

As the result of new anhydrite mining and sulphur recovery capacity, the potential domestic sulphur supplies increased significantly. In respect of anhydrite, to meet the requirements of two new anhydrite acid plants completed during 1955, mining operations started at Long Meg (annual capacity 240,000 tons) and St. Bees Head (annual capacity 360,000 tons) mines in Cumberland. The former, owned by British Plaster Board (Holdings) Ltd., supplies United Sulphuric Acid Corporation Ltd., Widnes, the latter supplies the Whitehaven plant of Solway Chemicals Ltd., who also own the mine.

Sulphur recovery capacity from oil refinery gases was increased with the start of operations of the trickle phase hydro-desulphurisation plant at the Stanlow refinery of Shell Petroleum Co., Ltd. Its potential output of 9,000 tons sulphur raises aggregate recovery capacity in the U.K. in the form of elemental sulphur or sulphuric acid to 55,000 tons per annum.

With the installation of a number of tower box purifiers of new design, the nationalised gas industry may be expected to improve the economics of their obligatory sulphur extraction operations. The North Thames Gas Board completed the installation of a hot potassium carbonate desulphurisation plant, the hydrogen sulphide yield of which is to be converted in a wet contact acid plant now under construction by Messrs. Huntington, Heberlein & Co.

It is estimated that the distribution of the various sources of domestic sulphur supply was as follows :—

Sulphur	*1954* *000 tons*	*1955*
In Anhydrite for direct ammonium sulphate manufacture	197	201
In Anhydrite for sulphuric acid manufacture	37	88
Recovered from coal gases	157	155
Recovered from oil refinery gases ...	32	38
In pyrites	2	2
In zinc smelter gases	59	60
	484	544

Consumption

The increase of about 3½% in total sulphur consumption is primarily attributable to the greater requirements of the sulphuric acid industry. Its level of production does not however, fully reflect the tenor of industrial activity in the United Kingdom, which during 1955 was about 5½% higher than in 1954. Comparative data are estimated as follows:—

000 Tons Sulphur	*1954*	*1955*	*Change %*
Anhydrite for direct manufacture of sulphate of ammonia ...	197	201	+2
For sulphuric acid manufacture	730	763	+4½
Other industrial uses ("Regular")	115	113	−1¾
	1,042	1,077	+3½

†The statistical data in this review include reliable estimates covering the activities of Solway Chemicals Ltd. in anhydrite acid manufacture and use.

As shown in the following table the proportionate use of indigenous raw materials has increased:—

	1954 %	1954 %	1955 %
Indigenous raw materials* ...	47½	45½	49¼
Imported brimstone	33½	31¼	30
Imported pyrites	19	22¼	20¼
Total Sulphur (000 Tons) ...	958	1,042	1,077

Under the impact of readily available low cost supplies of elemental sulphur the restrictions in its use in acid manufacture were not applied rigorously during the past year, so that the rising supplies of anhydrite acid were reflected primarily in the decreased use of spent oxide and pyrites. Consumption of imported "acid" sulphur increased slightly, to 248,600 tons, although the heavy acid requirements of the last quarter of 1955 raised its use to an annual level of over 280,000 tons.

Changes in the use of the various raw materials for sulphuric acid manufacture and industrial ("regular") purposes use were as follows:—

	1955 Tons	1954 Tons	Change %	4th Qtr. 1955 Tons	4th Qtr. 1954 Tons	Change %
Sulphur:						
Acid: Imported	248,600	—		5,800	—	
Recovered in H_2S and Filter cake	24,100	—		70,400	—	
Total "Acid" sulphur	272,700	258,400	+5½	76,200	68,000	+12
Regular	110,800	113,200	−2	30,200	30,400	−½
Total Sulphur	383,500	371,600	+3¼	106,400	98,400	+8¼
Pyrites	457,700	494,200	−7½	108,700	123,000	−11½
Spent Oxide	260,900	286,800	−9	65,400	69,800	−6¼
Anhydrite	417,200	176,700	+136	134,000	45,600	+194
Zinc Concentrates	200,400	198,000	+1¼	44,900	44,200	+1½

Changes month by month of the consumption of the various raw materials are shown in the following graph:—

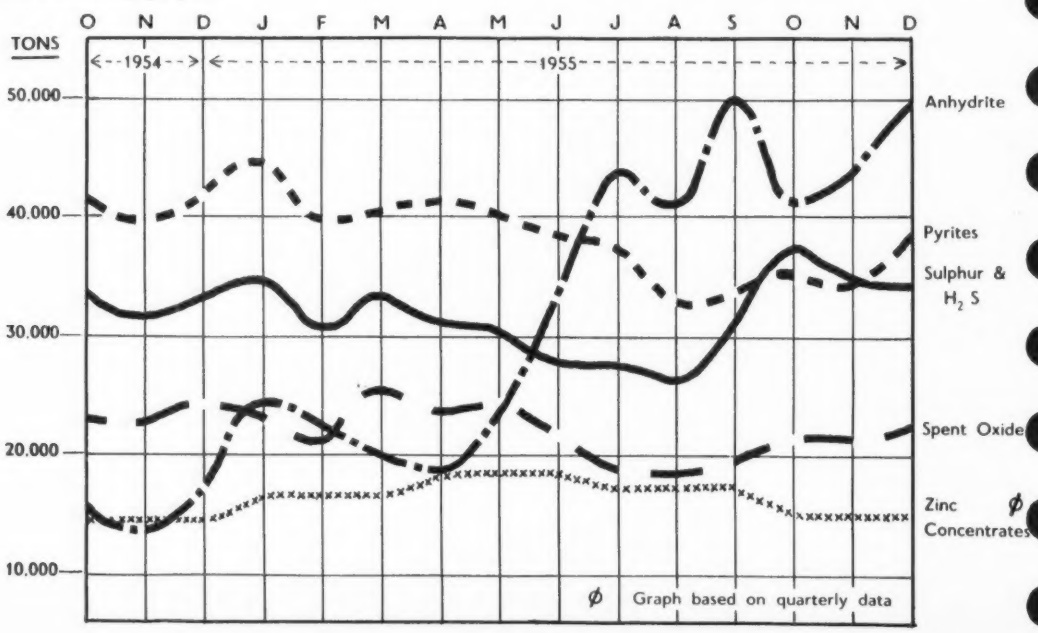


Fig. 9.

*Including Sulphur in anhydrite, spent oxide, zinc smelter gases, and recovered from oil refinery gases.

Elemental sulphur for regular uses

The decline in " regular " sulphur usage in 1955 is wholly attributable to the decreased consumption for the manufacture of carbon disulphide. This reduction does not, however, correspond to the trend of production of viscose rayon and transparent paper and may be attributable to changes in manufacturers stocks of CS_2. The largest proportionate increase in " regular " sulphur use is recorded in the manufacture of sulphur dioxide, sulphites, etc. Actual consumption for rubber compounding also increased, although requisitions, part of which went to make up depleted stocks, were greater in 1954.

Details are as follows:—

Consumption for :	*1954*	*1955*
	Tons	
CS_2	68,000	62,000
SO_2, Sulphites, etc.	12,000	14,000
Rubber compounding	11,000*	10,000
Agriculture	4,000	4,000
Dyes	5,000	5,000
Wood pulp	2,000	2,000
Export	1,800	2,200
Miscellaneous	11,200	13,800
	115,000	113,000

*Including about 3,000 tons to stocks.

It is estimated that about one-quarter of last year's regular sulphur consumption was met from indigenous sources.

Sulphuric Acid*

Production of sulphuric acid during 1955 amounted to 2,117,000 tons (100% H_2SO_4) an increase of 75,000 tons ($3\frac{3}{4}$%) compared with 1954 the previous peak year.

Whereas acid output during the first three-quarters of the year showed only relatively small increases compared with the corresponding period in 1954, production in the fourth quarter of 560,000 tons was the highest on record, and $9\frac{1}{4}$% greater than output during the fourth quarter 1954.

Acid production resulted from the use of sulphurous raw materials in the following proportions:—

During 1955 effective production capacity employed amounted to over 2.58 million tons (100% H_2SO_4), an increase of about 220,000 ($9\frac{1}{2}$%). The bulk of the increase is accounted for by the new anhydrite acid plants of I.C.I. at Billingham (73,000 tons per annum), United Sulphuric Acid Corp. Ltd., at Widnes (148,000 tons per annum, and Solway Chemicals Ltd., at Whitehaven (90,000 tons per annum), and the wet-contact acid plant of Brotherton Ltd., at Birmingham (3,000 tons per annum).

Only 81.2% of effective capacity was employed. It is estimated that brimstone plants operated at about 78% of capacity, pyrites roasters at about 75%, and spent oxide burners at about 83%. Of the total output of about 2.12 million tons, $72\frac{1}{2}$% was produced in contact plants, $27\frac{1}{2}$% in chamber and tower plants.

Acid Consumption

Consumption of sulphuric acid in 1955 was the highest on record, amounting to 2,137,000 tons (100% H_2SO_4), an increase of 86,000 tons ($4\frac{1}{2}$%) compared with 1954. The fourth quarter, usually a period of high consumption, was exceptionally so last year, and the use of 568,000 tons is the highest quarterly total on record.

Acid usage by the main consumer groups was approximately as follows:—

	1955	*%*	*1954*	*%*
Superphosphate	491	23.0	457	22.3
Ammoniam sulphate	285	13.3	290	14.1
Chemicals	270	12.6	280	13.7
Titanium and Lithopone	249	11.6	227	11.1
Rayon & transparent paper	261	12.2	248	12.1
Metallurgy	125	5.9	116	5.7
Oil Refining	61	2.9	55	2.7
Dyes	81	3.8	84	4.1
Soap and Detergents	58	2.7	48	2.3
Miscellaneous	256	12.0	243	11.9
	2,137	100	2,048	100

	1955	*4th Qtr. 1955*	*3rd Qtr. 1955*	*1954*	*4th Qtr. 1954*
	%	%	%	%	%
Sulphur :					
Imported Brimstone	$32\frac{3}{4}$	35	$30\frac{1}{2}$	$36\frac{1}{4}$	$37\frac{1}{4}$
Recovered in H_2S and Filter cake	3	3	$2\frac{3}{4}$		
Sulphur in :					
Pyrites	$28\frac{1}{2}$	$25\frac{3}{4}$	$27\frac{1}{2}$	$31\frac{3}{4}$	32
Spent Oxide	$16\frac{1}{2}$	$15\frac{1}{2}$	15	19	$18\frac{1}{2}$
Anhydrite	$11\frac{1}{2}$	14	$15\frac{1}{2}$	5	$5\frac{1}{4}$
Zinc Concentrate	$7\frac{3}{4}$	$6\frac{3}{4}$	$8\frac{3}{4}$	8	$7\frac{1}{4}$
Total sulphur (000 Tons)	763	201	180	730	183

*We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

Major changes in acid consumption comparing 1955 with the previous year were as follows :—

	Tons	+ %
Superphosphate	+33,900	+7½
Titanium Dioxide	+20,500	+10
Rayon & Transparent Paper ...	+12,500	+5
Soap, Glycerine, & Detergents ...	+10,500	+22
Iron Pickling	+9,100	+8½

The increased acid consumption in rayon manufacture is mainly due to the increased output of high tenacity yarn in which greater quantities of acid are used.

Other changes, though quantitively smaller, were recorded for sulphate of magnesium (—57%), agriculture (—39½%), Drugs and Fine Chemicals (—22%), Plastics (+21½%).

Trade† and Stocks

Imports of elemental sulphur during 1955 totalled 359,548 tons, valued at £15 per ton. The import bill of about £5.4 million, all but ½% dollar expenditure, was about £362,000 greater, although 16,300 tons less sulphur was imported.

Imports of pyrites valued at £7 9s. 6d. per ton totalled 497,020 tons in 1955, a reduction of over 100,000 tons compared with the preceding year.

Exports of ground and refined sulphur totalled about 2,200 tons, an increase of about 400 tons compared with 1954. Exports of spent oxide to the Continent are believed to have been maintained at about the previous year's level of 35,000-40,000 tons.

At the end of the year stocks of "acid" and "regular" sulphur, having increased 18,000 tons during the year, amounted to 85,200 tons, representing about fifteen weeks' supply at current rates of consumption. Stocks of pyrites increased 14,600 tons to 203,300 tons, whereas spent oxide stocks continued to decrease—17,000 tons during 1955—to 125,000 tons, each representing about 25 weeks' supply at the present rate of usage.

Prospects for 1956

The fiscal curbs on the economy which were instituted in recent months have already resulted in a slowing down of the expansion rate of industrial production, and in consequence they are likely to be reflected in the activities of the sulphur industry as a whole. Total consumption in 1956 is not expected to exceed 1.1 million tons sulphur, an increase of 2%, of which well over 50% should be met from indigenous sources; similarly sulphuric acid requirements are not likely to exceed 2.2 million tons (an increase of up to 3%). It is anticipated that of total acid supplies about 17%—375,000 tons—will be met in the form of anhydrite acid. No substantial change is expected in acid production from zinc smelter gases or from spent oxide, the latter promising to maintain its position in view of the favourable unit cost of sulphur and the constant improvement in quality resulting from the installation of an increasing number of up-to-date coal gas purification plants.

Although pyrites roasters may expect to continue benefitting from the better return on pyrites residues and the greater outlet for both fines and flotation cinders to the steel industry which they secured last year, the resultant reduction of acid production costs, estimated at about 22s. per ton of acid, or less than one half of the value realised by Continental roasters, is not thought to be sufficient to counteract the competitive advantage of supplies of sales acid based on other raw materials. In consequence, overall pyrites usage is expected to decline further by about 10%, any greater reduction being compensated by the requirements of the new turbulent layer pyrites roaster at the Grimsby plant of British Titan Products, which is starting operations this year.

Under the stimulus of ample supplies of low-cost elemental sulphur, a gradual increase of consumption is expected, as, subject to acid demand, brimstone burners may be operated more intensively and in preference to available alternative means of SO_2 generation. A number of new brimstone acid plants are projected, of which two — including a 50 ton per day contact plant which Simon-Carves Limited are building for Messrs. R. & J. Garroway at Glasgow—are under construction.

These projects are not likely to affect the pattern of consumption in 1956 which, after a period of adjustment, is expected to emerge clearly in the latter half of the year.

†For details, see Statistical Appendix.

Nairne Pyrites

On 13th February the new ore treatment plant at Nairne, South Australia, was officially opened by the Premier of South Australia, The Hon. Thomas Playford, M.P. Designed

General View: Crushing and Screening plant in foreground. Flotation plant and Tailings Thickener in centre.

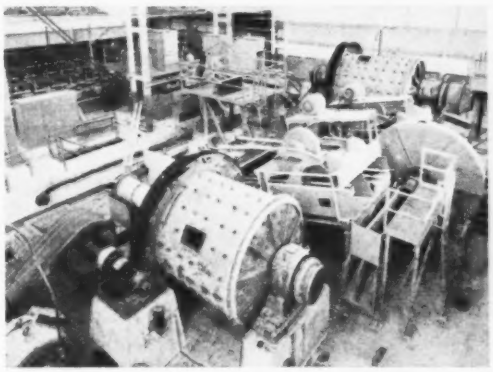
specifically to treat ore from the large pyritic deposit at Brukunga, three and a half miles north of Nairne, the plant has in fact been operating since the 17th June, 1955. This deposit, although known for eighty years, was not seriously considered as suitable for development until the world shortage of sulphur in 1951. With the support of the South Australian Government the three leading South Australian Fertiliser Manufacturers—Cresco Fertilisers Limited, Adelaide Chemical & Fertiliser Company Limited and Wallaroo-Mount Lyell Fertilisers Limited—joined by the Broken Hill A.S. Pty. Ltd., as managing agents, formed Nairne Pyrites Limited with a view to providing an indigenous source of sulphur to meet the rising sulphuric acid requirements of the fertiliser industry of South Australia.

Exploration at Brukunga by the South Australian Mines Department disclosed the presence of workable deposits of sulphide ore, mainly occurring in prominent bands following the bedding of the rock. The ore bodies contain principally pyrite, pyrrhotite in varying amounts and some marcasite and traces of arsenopyrite, chalcopyrite, and sphalerite. The deposit is 300 feet wide over a distance of 3 miles from north to south and dips steeply to the east.

The ore, containing 4-14% sulphur, is mined by open-cast quarrying and trucked to the crushing plant. It is end dumped into a hopper, the base of which is formed by the pallets of the pan feeder which, travelling at 11.2 feet per minute, discharges directly into the jaws of a 60 × 48 inch "Ruwolt" primary crusher.

Description of Plant

From the underside of the crusher, the ore passes by chute on to a 54 inch belt conveyor travelling at 260 feet per minute which discharges into a bifurcating chute feeding the ore to two secondary crushers. These are 4 feet "Traylor" T.Y. gyratory crushers with a 2 inch discharge setting.



Grinding section of the plant showing rod mill and ball mill. Flotation cells in left background.

The secondary crushed ore passes on to a 36 inch conveyor and is lifted to the screening plant which contains two Symons' Rod Deck Screens—8 by 5 feet—the rods of which provide a ½ inch gap. The oversize from the screens is lifted by a conveyor belt to the surge bin which has a capacity of 700 tons.

A regulated feed from the surge bin is provided by the use of an electrical vibrating feeder which discharges on to a 30 inch conveyor. This conveyor elevates the ore which then passes to two tertiary crushers.

These units are Symons' 4 feet standard cone crushers, which are set to $\frac{3}{8}$ inch. The tertiary crushed ore passes on to the same conveyor that receives the ore from the secondary crushers and is thus elevated to the screening plant. This establishes a closed circuit and the ore continues to receive tertiary crushing until sufficiently reduced in size to pass through the screen openings.

The undersize from the screens is elevated to the mill storage bin which has a capacity of 2,000 tons and is situated near the milling and flotation plant.

Vibrating feeders, located under the mill storage bin, feed the ore on to an 18 inch conveyor belt which, after passing over a "Blake Denison" weigher, discharges into an 8 by 10 feet rod mill. The mill operates on open circuit and discharges into No. 1 classifier. The sands from this classifier are transferred by means of a scoop conveyor into the ball mill—8 by 7 feet—the discharge from which is pumped by a 6-4 "Warman" pump to an elevated distributor situated above the two classifiers. The purpose of the distributor is to divide the ball mill discharge so that desired quantities are passed to Nos. 1 and 2 classifiers, thus loading both classifiers equally. The two classifiers are identical and are 8 by $25\frac{1}{2}$ feet "Dorr" D.S.F.X. type set at an angle of 3 inches in 12 inches.

The classifier overflow is pumped to an elevated position and is passed through conditioners to the rougher cells.

The flotation section consists of three banks of No. 21 "Denver" cells, each bank consisting of eight cells. Two banks are rougher cells and the remaining bank cleaner cells.

The tailings are thickened in a 120 feet torque type thickener and then pumped by "Warman" pumps through a 6 inch pipeline to the tailings dam. Water from the dam is returned from the dam site by pumping to the mill circuit tank.

The concentrates, after being thickened in the 50 feet thickener, are pumped to the agitators and then to the filter house. This house contains an $8\frac{1}{2}$ feet diameter disc filter and sufficient room has been provided to instal a second filter of this type.

The filter cake drops from the filter on to an 18 inch conveyor belt which discharges into the hopper of the swivel piler. This unit projects the concentrates into the storage shed and pivots about a vertical axis to give comparatively large storage with limited headroom.

From the shed the concentrates are trucked $3\frac{1}{2}$ miles to Nairne for onward rail transport. This project entailed building the road from Brukunga to Nairne, the construction of a railway track to connect with the main Adelaide-Melbourne line, the provision of a temporary water supply from a well at Woodside, from which water is piped to a concrete storage tank of $\frac{1}{2}$ million gallon capacity, while the Mannum-Adelaide pipeline is under

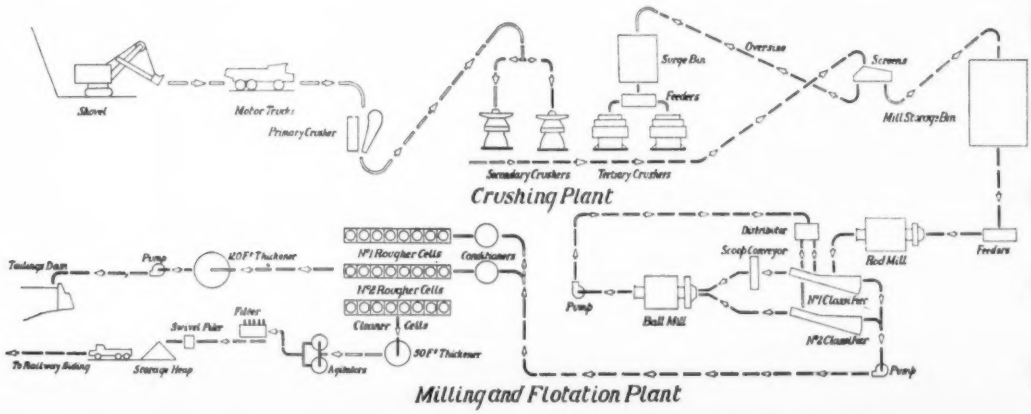


Fig. 10. Flowsheet. In practice there is a circulating system between the banks of the Rougher and the Cleaner Cells.

construction and the installation of a sub-station and transformer bank to reduce from 33 K.V. to 3.3 K.V. the power taken off the main transmission line.

The ore treatment plant is designed to produce concentrates with a sulphur content of 47-49% sulphur at a rate of 30,000 to 33,000 tons sulphur per annum. The first consignment of concentrates was despatched on 4th July 1955 to the new recently constructed plant of Sulphuric Acid Ltd., at Birkenhead, 8 miles N.W. of Adelaide. Built by Simon-Carves Ltd., it is a contact acid plant designed to produce 300 tons acid per day (100% H_2SO_4) and is integrated with the Nairne Pyrites Plant. Up to the beginning of February, 1956, 40,000 tons acid (100% H_2SO_4) were produced by Sulphuric Acid Ltd., from Nairne pyrites concentrates containing the equivalent of 15,000 tons sulphur.

As anticipated during the Tariff Board's enquiry the cost of production of sulphuric acid from Nairne pyrites exceeds the comparable cost of brimstone acid with the result that the operations of Sulphuric Acid Limited qualify for the payment of the sulphur bounty at a time of ample world supplies of brimstone. Although the provision of this new sulphuric acid capacity in South Australia was essential to meet rising acid requirements it is questionable whether the heavy capital expenditure would have been incurred in the development of the Nairne deposit and the construction of the ore treatment plant, had the sulphur crisis not produced a strong desire for national self sufficiency in sulphur supplies.

Current Events

AUSTRALIA

Sulphur Recovery from Lead Sinter Gases

Reconstruction of the sintering machines and exhaust system at the lead sintering plant of Broken Hill Associated Smelters Pty. Limited at Port Pirie, South Australia, to permit the use of sulphur contained in the form of SO_2 in the sinter gases, was completed in January, 1956. The new sintering machine uses an upward flow of air through the charge-bed instead of the normal downward flow.

The gas containing average of 6½% SO_2 is fed after purification to a contact acid converter thus supplanting the established supply of SO_2 gas from a brimstone burner. Sulphur from the sinter gases is recovered at a rate of 16,000-18,000 tons per annum permitting the manufacture of about 45,000-50,000 tons sulphuric acid (100% H_2SO_4), subject to the continuity of operation of the sintering plant.

The bulk of the acid supplies is used for the manufacture of superphosphates by The Adelaide Chemical and Fertilizer Co. Ltd., Cresco Fertilizer Ltd., and Wallaroo Mount Lyell Fertilizers Ltd.

CANADA

Athabasca Tar Sands

Economic exploitation of oil and sulphur from the vast tar sand deposits along the Athabasca River, north of Fort McMurray, promises to be realised in the foreseeable future.

Can-Amera Oil Sands Development Limited of Calgary working in partnership with Royalite Oil Company have started to reconstruct the experimental plant at Bitumount, which they purchased from the Alberta Government eighteen months ago, with a view to adapting it to the separation process developed by their Chief Engineer Mr. G. R. Coulson.

Exploitation of the Company's concession area of 5,874 acres near Bitumount and the installation of a commercial scale processing plant, will necessitate capital expenditure of $35-50 million. The installations are to include separating plants operating in banks of twenty, a coking plant, a sulphur recovery unit and 10¾" oil pipe line from Bitumount to Edmonton, a distance of 300 miles.

Early this year Consolidated Mic Mac Oil Limited of Edmonton acquired a 50,000 acre concession in the Tar Sands area and it is reported that this company too is is planning early exploitation.

The tar sands contain about 15% bitumen, 85% of which is recoverable by primary separation. The conversion of the bitumen to marketable oil products necessitates, amongst other treatment, the extraction of the sulphur content of 4-5% of which about 60%

is recoverable. A plant processing 20,000 barrels bitumen per day, approximately equivalent to one acre of tar sands, would yield about 45,000 tons sulphur annually. Total oil reserves of the Athabasca deposit are estimated at 350 billion barrels.

Exploration by Texas Gulf Sulphur Company

In the course of an exploratory drilling programme in New Brunswick carried out by Middle River Mines Limited, a wholly owned subsidiary of Texas Gulf Sulphur Company, an important lead-zinc sulphide ore body has been discovered some ten miles west of the deposits of the American Metal Company. Middle River Mines Limited, who have 500-600 claim holdings to the north and east of the new deposit, are continuing their exploratory drilling programme in the area.

New Sulphur Recovery Project

The Pacific Petroleum Company and its associates have announced plans to build an $18 million gas treatment and sulphur recovery plant, designed to process natural gas from the Peace River field of British Columbia and Alberta.

The new plant will have a daily throughput capacity of up to 300 million cubic feet gas and treatment will permit the extraction of liquid hydrocarbons and of hydrogen sulphide which is to be recovered in the form of high purity elemental sulphur. Based on the composition of the crude gas it is estimated that daily output will amount to 1,700 barrels of gasolene, 500 barrels of diesel oil, 300 barrels of propane, 600 barrels of butane, and two hundred and seventy five tons of sulphur. The plant is to come on-stream by the autumn of 1957 when the $150 million West Coast pipeline is also due to be completed. This pipeline, operated by West Coast Transmission Limited, will carry the cleaned gas through British Columbia to the U.S. Pacific Northwest.

In November of last year the U.S. Federal Power Commission authorised the Pacific Northwest Pipeline Corporation to import from Canada up to three hundred million cubic feet of gas per day, which is intended to supplement the gas supplies to Oregon, Washington, and Idaho States, which the Corporation is bringing by a pipeline from the San Juan basin of New Mexico and Colorado. The assurance of the stable outlet in the U.S.A. will enable West Coast Transmission Limited to provide low cost gas to British Columbia and in particular to promote the development in Peace River County around Fort St. John and Dawson Creek.

Expansion Plans of Canadian Gulf Oil Company

The start of construction work on the new gas treatment and sulphur recovery plant at Pincher Creek which, when completed in September 1956, will produce 225 tons sulphur per day is the first step in the Company's plans for the large scale exploitation of Alberta's natural gas wealth and concomitant arising of sulphur.

Initially the plant, which is based on a daily sour gas throughput of 60 million cubic feet, will extract only hydrogen sulphide and 2,200 barrels of condensate per day, while the remaining gas and lighter fractions will be returned to the formation. As soon as Trans-Canada Pipe Lines Ltd. are in operation and call for the contracted daily supplies of 100 million cubic feet in the first year, the plant will be expanded and will extract liquid hydrocarbons as well as condensate and hydrogen sulphide.

The estimated recoveries in the first year and in the second year when gas deliveries to Trans-Canada Pipe Lines Ltd. are stepped up to 170 million cubic feet daily are shown below. In subsequent years these amounts will vary slightly. At the same time the Company has completed exploratory work at the Nevis Gas Field, ninety miles north of Calgary, where within two to three years it is proposed to start exploitation leading to the recovery of 325 tons sulphur per day.

	1st Year.	*2nd Year.*
	000 Barrels.	
Propane	267	462
Butanes	268	480
Natural gasoline ...	215	365
Condensate ...	1,700	2,900
	000 Tons.	
Elemental sulphur ...	115	307

Both Pincher Creek and Nevis Gas Fields are amongst the largest in Alberta, with gas reserves estimated to permit production for at least forty and thirty years respectively at the rates indicated above. Taken in conjunction with the established level of sulphur recovery from natural sour gas of about 36,000 tons by the Shell Oil Company of Canada at Jumping Pound and Royalite Oil Company at Turner

Valley, and the projected new recovery plant of Pacific Petroleum Company, the expansion plans of Canadian Gulf Company promise to raise Western Canada's contribution to world supplies to over one-half million tons sulphur annually.

UNITED STATES

Fertilizer Plant Extension

A $2 million expansion project at the Garfield plant of Western Phosphate Incorporated, a joint affiliate of Stauffer Chemical Company, American Smelting and Refining Company and Kennecott Copper Corporation is due to be completed late in 1956, when the production of ammoniated phosphates and triple superphosphates will be increased by 40%. The consumption of sulphuric acid, at present at a daily rate of 250 short tons (100% H_2SO_4), will be raised to 365 tons. Sulphuric acid requirements are met wholly by the Garfield Chemical and Manufacturing Co. Ltd., who are also stockholders of Western Phosphates Inc.

To meet the additional acid demand the Garfield Chemical and Manufacturing Co. Ltd.—a subsidiary of ASARCO and Kennecott Copper Corporation—are to increase their acid making facilities to 1,000 tons per day and are constructing a 250 tons per day acid plant at an estimated cost of $2½ million. The company's acid operations are based on the use of sulphur in smelter gases.

New Process Control in Sulphur Recovery

The efficiency of sulphur recovery processes from H_2S, whereby the latter is burnt in the presence of air to sulphur dioxide which in turn reacts with more sulphide to yield elemental sulphur and water, is primarily determined by the correct ratio of air to H_2S. Practically without exception plants at present in operation control the ratio of air to feed-gas. As the exact H_2S content of the feed-gas varies, there is an inevitable sulphur loss, which moreover results in an air pollution problem.

The Consolidated Electrodynamics Corporation of Pasadena (California) have studied this problem and recently completed plant-scale experiments on a mass spectrometer which by constantly and automatically determining the H_2S content of the feed-gas permits an accurate control of the admixture of air. In the course of the experiments C.E.C. found that a 40 ton per day sulphur recovery plant at times wasted sulphur at a rate of 17 tons a day and that the average loss was 1.2 tons. The company estimated that the saving from improved sulphur recovery is such that the cost of the mass spectrometer can be recovered in 314 days operation. The rising trend of elemental sulphur and sulphuric acid production from H_2S recovered from natural, oil refinery and coal gases holds promise of wide application of this new means of process control.

New Vulcanising Agent

Following the announcement last May by the Hercules Powder Company of Wilmington Delaware that they had developed a new chemical which could replace sulphur as vulcanising agent of natural rubber, detailed tests to evaluate it have been carried out in the U.S.A. and in this country. The chemical, dicumyl-peroxide, trade name 'Di-cup,' was claimed to have all the advantages of sulphur in vulcanisation and none of the disadvantages. In particular, it would eliminate the need for 2 or 3 regular catalysts used in sulphur vulcanisation, which are expensive, and it could be used to advantage in the manufacture of light coloured rubbers.

Tests carried out in this country have corroborated its useful application in the manufacturing of rubber where its good-ageing and non-discolouring properties are of importance. On the other hand dicumyl-peroxide compounds showed low tear resistance. In general it was found that substitution of sulphur could be effected by Di-Cup, but further work is necessary on anti-oxidants, accelerators, and like materials before it is likely to achieve general acceptance. Cost is also a factor requiring consideration, but a reasonable reduction in price can be expected when Di-Cup is in volume production.

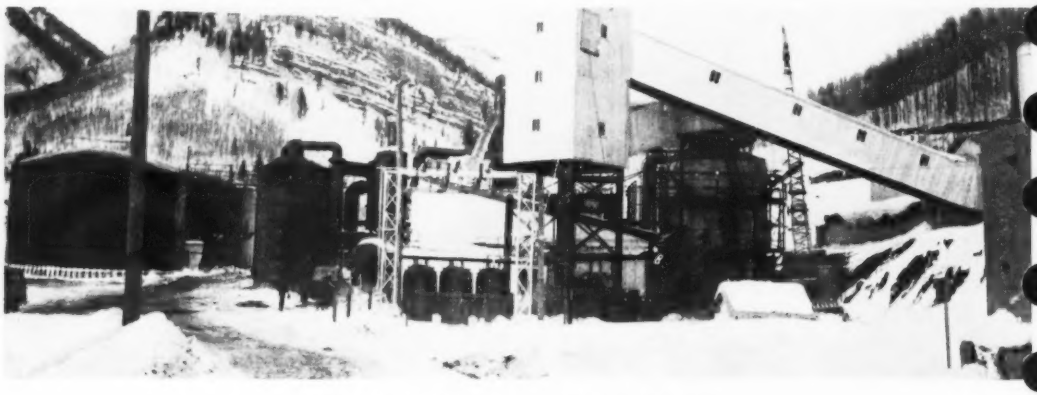
Dicumyl-peroxide has so far only been manufactured by Hercules Powder Co. on an experimental scale and the decision whether or not to engage in commercial scale production will not be taken, until the limited number of rubber users to whom the chemical was submitted have completed tests.

New Sulphuric Acid Plant

In September 1955 the Rico Argentine Mining Company commenced operations at Rico Colorado of a new $1.4 million sulphuric acid plant which, situated at a height of 8,835 feet, is the second highest in the world. The plant has a capacity of 200 tons per day (100% H_2SO_4) and is based on pyritic tailings, with a content of 30-45% sulphur, which have accumulated from the flotation of lead-zinc sulphide ores, at present totalling ¼ million tons and arising at a monthly rate of 1,500 tons.

The raw material is fed by a conveyor directly to a Dorr Fluo-Solids roaster. The roaster gases pass through a Peabody scrubber and a mist precipitator; the cleaned gas is converted in a Leonard Monsanto contact acid plant of standard design.

The present stock of pyritic tailings is expected to supply the plant for two years; thereafter a local pyritic ore body is to be mined and development plans are now being prepared. This ore, which has a content of approximately 50% sulphur, is to be mined at a rate of up to 50,000 tons per annum and it is envisaged that after crushing to minus ¼", it will be fed in dry form, directly to the roaster. The current acid output is supplied to a number of uranium ore leaching plants including the U.S. Atomic Energy Commission's mill at Monticello, Utah, two Colorado mills of the Vanadium Corporation of America and to the mill of Kerr-McGee Oil Industries Inc. at Shiprock, Arizona.



Rico Argentine Mining Company's new acid plant.

FRANCE

Amalgamation of French Sulphur Refining Companies

Following recent negotiations, Les Raffineries de Soufre Réunies of Marseilles has assumed control of the Société Continentale des Raffineries de Soufre Réunies, the French subsidiary of Montecatini of Milan.

Les Raffineries de Soufre Réunies is the largest sulphur refiner in France, and supplies more than half of the French sulphur requirements, which are estimated to be 180,000 tons annually. The amalgamation will permit the facilities of Société Continentale des Raffineries de Soufre Réunies, who operate sulphur refining plants in Marseilles and Sète, and have two plants on hire, to be closely integrated with the facilities of the new parent company. It is anticipated that the reorganisation of plants and output will result in considerable economies.

SYRIA

Native Sulphur Discovery

According to an announcement in January 1956 by the Director of the Mineral Department of Syria a major deposit of sulphur and asphalt has been discovered in Northern Syria at Lake Ras-el-Ain. The sulphur deposit appears to be of sedimentary origin and is associated with gypsum strata at depth. A representative sample indicated a content of 70% free sulphur. An interesting phenomenon of the deposit is that it is self-replenishing.

Statistical Appendix

Italy

CRUDE SULPHUR PRODUCTION
(000 Metric Tons)

Average	1896-1900	509	1946	143
„	1901-1905	551	1947	148
„	1906-1910	448	1948	174
„	1911-1915	385	1949	188
„	1916-1920	241	1950	213
„	1921-1925	251	1951	214
„	1926-1930	309	1952	236
„	1931-1935	347	1953	223
„	1936-1940	348	1954	204
„	1941-1945	163	1955	185

CRUDE SULPHUR EXPORTS
(000 Metric Tons)

1938	... 200.8	1951	...	80.2
1946	... 10.5	1952	...	51.6
1947	... 13.7	1953	...	7.1
1948	... 70.2	1954	...	0.5
1949	... 45.8	1955	...	46.8
1950	... 201.5			

PYRITES PRODUCTION
(000 Metric Tons)

		Italy	*Montecatini*
Average	1930-1934	685	586
„	1935-1939	905	800
„	1940-1944	812	727
	1945	108	102
	1946	401	368
	1947	643	579
	1948	836	737
	1949	864	731
	1950	900	747
	1951	898	775
	1952	1,141	970
	1953	1,225	1,050
	1954	1,232	1,066
	1955	1,290	1,147†
	1956	1371	

†Provisional data

PYRITES EXPORTS
(000 Metric Tons)

	Switzerland	*Austria*	*Holland*	*France*	*Others*	*Total*
1938 ...	14.0	—	22.9	12.7	43.7	93.3
1945 ...	—	—	—	—	—	—
1946 ...	32.8	8.4	—	83.9	20.9	146.0
1947 ...	36.0	7.4	—	—	29.8	73.2
1948 ...	42.6	20.9	—	—	19.4	82.9
1949 ...	24.6	14.9	—	—	49.1	88.6
1950 ...	42.3	27.3	—	—	20.2	89.8
1951 ...	43.5	4.5	65.7	—	35.3	149.0
1952 ...	42.5	1.2	21.8	—	37.2	102.7
1953 ...	35.7	13.2	9.4	—	1.9	60.2
1954 ...	57.3	43.3	—	—	15.8	116.4
1955 ...	50.5	36.6	—	—	11.5	103.0†

†Estimated figure for 1955, based on first 11 months as shown

PYRITES IMPORTS
(000 Metric Tons)

	Cyprus	*Greece*	*Spain*	*Cuba*	*Others*	*Total*
1938 ...	—	5.0	14.8	—	—	19.8
1946 ...	—	—	—	—	—	—
1947 ...	—	12.5	4.9	—	—	17.4
1948 ...	—	18.7	—	—	—	18.7
1949 ...	56.5	2.9	—	—	—	59.4
1950 ...	61.1	19.2	35.6	—	0.7	116.6
1951 ...	107.1	15.3	75.3	—	3.3	201.0
1952 ...	87.3	—	—	—	0.9	88.2
1953 ...	72.3	—	24.0	10.2	9.9	116.4
1954 ...	50.5	11.8	—	55.2	66.8	184.3
1955* ...	58.9	28.2	40.8	29.7	31.3	188.9

*First 11 months of 1955.

United Kingdom

SULPHURIC ACID CONSUMPTION

(Thousand Tons 100% H_2SO_4)

	1954	1955
Accumulators	9.3	10.9
Agricultural Purposes	8.2	5.0
Bichromate and Chromic Acid	14.6	15.6
Bromine	21.9	12.2
Clays	10.5	11.5
Copper Pickling	2.7	3.1
Dealers	14.2	13.8
Drugs and Fine Chemicals	24.0	18.7
Dyestuffs and Intermediates	83.8	81.5
Explosives	32.1	28.9
Export	3.4	3.8
Glue	0.5	0.4
Hydrochloric Acid	60.3	61.6
Hydrofluoric Acid	12.0	11.4
Iron Pickling	108.5	117.6
Leather	4.8	5.0
Lithopone	15.6	16.8
Metal Extraction	4.3	4.3
Oil Refining	54.8	60.6
Oils (Vegetable)	11.7	11.2
Paper, etc.	7.3	7.4
Phosphates (Industrial)	1.1	0.6
Plastics	28.8	35.0
Rayon and Transparent Paper	248.2	260.6
Sewage	11.1	11.0
Soap, Glycerine, & Detergents	47.7	58.2
Sugar Refining	0.6	0.6
Sulphate of Ammonia	290.3	284.6
Sulphates of Copper, Nickel, etc.	23.1	20.4
Sulphate of Magnesium	4.9	2.1
Superphosphate	457.1	491.0
Tar and Benzole	23.0	23.2
Textiles	20.5	19.2
Titanium Oxide	211.3	231.8
Unclassified	175.5	197.2
Total	2,047.7	2,136.8

SULPHUR IMPORTS

Country of origin	*1955 Tons*	*Value per ton* £ s.	*1954 Tons*	*Value per ton* £ s.
U.S.A.	332,568	15 1	369,851	13 7
Mexico	25,271	13 19	—	—
Trinidad	1,575	14 15	2,798	12 10
Norway	—	—	1,267	15 6
Others	134	72 10	1,981	18 11
	359,548	15 0	375,877	13 8

PYRITES IMPORTS

Country of Origin	*Tons*	*Value per ton* £ s.
Cyprus	217,879	7 11
Canada	66,323	7 3
Norway	14,464	7 3
Portugal	1,799	8 5
Spain	191,706	7 11
Sweden	4,849	7 7
Total	497,020	7 10

SULPHUR EXPORTS—1955

	Long Tons.
Canada	348,339
Cuba	14,700
Mexico	3,646
N. Antilles	4,000
Dominican Rep.	500
Venezeula	1,380
Brazil	75,502
Colombia	89
Argentina	9,842
Uruguay	6,516
Peru	213
United Kingdom	294,699
Austria	6,120
Belgium	73,199
Finland	8,738
France	127,360
Netherlands	10,718
Spain	14,284
Switzerland	61,822
W. Germany	39,048
French Morocco	7,500
Algeria	12,000
Tunisia	12,000
Egypt	787
U. of South Africa	78,500
Israel	400
Aden	577
Bahrein	509
Iraq	2,581
Pakistan	1,619
India	75,215
Hong Kong	750
Australia	171,412
New Zealand	119,068
Indonesia	8,190
Philippine Rep.	3,600

Total ... 1,595,423

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LARGEST producer of Mexican Sulphur.

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